APPENDIX C.4

FACILITY ACCIDENTS

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C.4 Facility Accidents

C.4.1 FACILITY OPERATIONAL ACCIDENTS FOR WASTE PROCESSING ALTERNATIVES

C.4.1.1 Introduction

C.4.1.1.1 Purpose

The purpose of Section C.4.1 is to present supporting analysis information for Section 5.2.14, Facility Accidents, including the three potential bounding accidents (abnormal events, design basis events, and beyond design basis events) for each of the 9 waste processing alternatives/options. Seventy-two bounding accidents are discussed in Section C.4.1.3 and C.4.1.4. The major process elements and their relation to the waste processing alternatives are shown in Table C.4-1.

C.4.1.1.2 Accident Analysis Definitions

The National Environmental Policy Act defines accidents as undesired events, or combinations of events, that can occur during or as a result of implementing an alternative and that have the potential to result in human health impacts and environmental impacts. Human health impacts could result from exposure to direct health impacts, such as exposure to fires or explosions, ionizing radiation, radiological or chemically hazardous releases, or combinations of these hazards. Environmental impacts include such effects as land use restrictions, ecological damage, and damage to or loss of natural resources. Facility accidents may provide a key discriminator among waste processing alternatives, particularly if the potential for accident impacts varies substantively for the different facilities and operations associated with the alternatives.

Environmental impacts are associated with existing environmental contamination or with materials that could constitute a hazard to humans or the ecology if released during an accident. The purpose of implementing any of the waste processing alternatives is to reduce existing impacts posed by calcine and SBW in their present forms. In addition, the waste processing alternatives are associated with HLW facilities that may require eventual dispositioning. Reduction of environmental risk is accomplished by elimination or control of hazards associated with materials at a facility by removing them, rendering them immobile, or rendering them otherwise inaccessible to human or environmental contact. This constitutes

Table C.4-1. Process elements and waste processing alternatives.[a]

AA[b]	Processing elements \ **Waste processing alternatives**	**No Action Alternative**	**Continued Current Operations Alternative**	**Full Separations Option**	**Planning Basis Option**	**Transuranic Separations Option**	**Hot Isostatic Pressed Waste Option**	**Direct Cement Waste Option**	**Early Vitrification Option**	**Minimum INEEL Processing Alternative**
1	New Waste Calcining Facility Continued Operation		X		X		X	X		
2	New Waste Calcining Facility High Temp & Maximum Achievable Control Technology Modifications		X		X		X	X		
3	Calcine Retrieval and Onsite Transport	X	X	X	X	X	X	X	X	X
4	Full Separations			X	X					
5	Transuranic Separations (TRUEX)					X				
6	Cesium Separations (Cesium Ion Exchange)		X							X
7	Class C Grout					X				X
8	Borosilicate Vitrification (Cesium, Transuranic, Strontium)			X	X					
9	Borosilicate Vitrification (Calcine & SBW)								X	
10	HLW/SBW Immobilization for Transport (Calcine & Cs IX)									X
11	HLW/SBW Immobilization for Transport (HIP)						X			
12	HLW/SBW Immobilization for Transport (Direct Cement)							X		
13	HLW/SBW Immobilization for Transport (Calcine & SBW)	-- Not used --								
14	Liquid Waste Stream Evaporation		X	X	X	X	X	X		
15	Additional Off-Gas Treatment			X	X	X	X	X	X	X
16	Class C Grout Disposal					X				
17	HLW Interim Storage for Transport									X
18	HLW/HAW Stabilization and Preparation for Transport									X
19	HLW/HAW Stabilization and Preparation for Transport	-- Not used --								
20	Long-Term Onsite Storage of Calcine in bin sets	X	X							
21	Transuranic Stabilization and Preparation for Transport to Waste Isolation Pilot Plant		X		X	X	X	X		X
22	Long-Term Onsite Storage of SBW	X								
23	SBW Stabilization and Preparation for Transport to Waste Isolation Pilot Plant								X	
24	SBW Retrieval and Onsite Transport		X	X	X	X	X	X	X	X

a. Two accident analyses (13 and 19) are no longer used. Neither of these accident analyses will be discussed further in this appendix.
b. Accident Analyses as defined in the Technical Resource Document (DOE 1999).
Cs IX = cesium ion exchange; HAW = high-activity waste; HIP = Hot Isostatic Press.

a reduction in the potential for long-term exposures to the public or the environment, which is called environmental risk reduction. Existing hazards that would represent a risk to humans and the ecological environment, if they are not mitigated, may be thought of as the “risk of doing nothing.” The effectiveness of environmental risk reduction is a discriminator among the potential waste processing alternatives.

During implementation, each of the waste processing alternatives temporarily adds risk to humans and the environment during the life of the project. Implementation risk results from the activities associated with implementing a waste processing alternative. This implementation risk, which can be thought of as the “risk of doing something,” is illustrated qualitatively in Figure C.4-1 as the potentially negative impact of a waste processing alternative. Implementation risk to humans is the sum of risk from facility accidents (i.e., accidents involving release of or exposure to radioactive or chemical materials, transportation accidents, industrial accidents, and accrued occupational exposures during operations). Facility accidents involve risk to the public and are a potential discriminator for waste processing alternatives.

Observational data is not available to predict future performance of planned HLW facilities. Safety assurance documents such as facility safety analysis reports and safety analysis reports for packaging provide a perspective on safety issues and their resolution in DOE facilities and operations. However, these documents are used mainly to identify design features and operational controls that control risk to the public. A perspective on the implementation risk for waste processing alternatives is obtained through an analysis of radiological and toxicological accidents supported by the *Idaho High-Level Waste and Facilities Disposition EIS Facility Accidents Technical Resource Document* (DOE 1999), which is referred to as the TRD in this Appendix.

Facility accidents would not be expected to be the dominant source of implementation risk to workers for waste processing alternatives. The relative contribution to worker risk of facility accidents, industrial accidents, and occupational exposures is shown conceptually in Figure C.4-2. Figure C.4-2 shows that implementation risk is more likely to be dominated by industrial accidents and unavoidable occupational exposures. Facility accident risks to workers would be dependent on the effectiveness of environmental safety and health management at future facilities associated with HLW treatment. An effective environmental, safety, and health program that manages risk to workers and the public is assumed in this accident analysis.

Consequences of industrial accidents can involve fatalities, injuries, or illnesses. Fatalities can be prompt (immediate), such as in construction accidents, or latent (delayed), such as cancer caused from radiation

exposure. While public comments received in scoping meetings for this EIS included concerns about potential accidents, the historical record shows the industrial accident rate for DOE facilities at the INEEL is somewhat lower (Millet 1998) compared to the rate in the DOE complex overall. The historic accident rate also compares favorably to national average rates compiled for various industrial groups by the National Safety Council (NSC 1993) and Idaho averages compiled from state statistics (DOE 1993a). One measure of the expected effectiveness of site management in controlling facility accident risks at future facilities is the effectiveness of current management in controlling risk to workers. The Computerized Accident Incident Reporting System database that chronicles injuries, accidents, and fatalities to workers at INEEL can be used as a measure of management effectiveness in controlling the risk of fatal industrial accidents to involved and noninvolved workers. This assumption is based on the fact that control over all accidents in the workplace is a requirement for controlling fatal accidents. Historically at INEEL, fatal accidents represent approximately 0.1 percent of all accidents. Accident data is typically collected in terms of different types of activities. From the SNF & INEL EIS (DOE 1995), the rate of injury/illness for construction activities in the DOE complex was 6.2/100 worker-years, and the rate of injury/illness for construction activities in private industry was 13/100 worker-years from 1988-1992. From 1993-1997, the rate of injury/illness for construction activities at INEEL was 5.4 per 100 worker-years (Fong 1999). This data supports the conclusion that the injury/illness rate at INEEL is slightly lower than DOE as a whole and significantly lower than private industry. The fatality rate from 1993-1997 was 0.05 per 100 worker-years which is higher than the previously reported fatality rate for the period 1988-1992 and is due to the occurrence of a fatality at the INEEL in 1996. An additional INEEL fatality occurred in 1998. Incorporating this 1998 fatality into the industrial accident rate using a Bayesian update results in a fatality rate of 0.14 per 100 worker-years, which is clearly greater than the fatality rate for the DOE complex as a whole. However, a comprehensive correction action effort is currently being implemented to control and reduce the industrial accident rate at the INEEL. Over the time period of this EIS it can be assumed that the fatality rate at the INEEL will be similar to or better than that of the DOE complex as a whole.

Waste processing alternatives and options being considered in this EIS require an analysis of facility accidents as one of the impacts associated with implementation. The scope of the accident analysis is to evaluate, for each waste processing alternative, the potential for facility accidents that would not necessarily occur but which are reasonably foreseeable and could result in significant impacts (DOE 1993b). The accident analysis must be sufficiently comprehensive to inform the public and other stakeholders of possible impacts and tradeoffs among major waste processing alternatives. Although most safety assurance evaluations of facility accidents indicate that industrial accidents are the largest single contributor to the overall health and safety risk to workers associated with the implementation of an alternative, industrial accident risks are evaluated separately in this EIS (Section 5.2.10) and are not part of the scope of the accident analysis.

The EIS accident analysis requires a technical information base that includes descriptions of potentially bounding accidents (scenarios), as well as the likelihood, source term, and predicted consequences of each accident. Given the large number of alternatives being considered for HLW management and the extensive number of activities associated with implementing each alternative, development of a comprehensive technical basis for identifying and evaluating bounding accidents poses a significant challenge to the National Environmental Policy Act process. The TRD has been assembled to provide a comprehensive and easily referenced source of information for facility accident analysis in the Idaho HLW & FD EIS and is the basis of this appendix.

Since future facilities must be designed and operated to mitigate the risk of accidents, the accident analysis in the TRD is intended to form a functional safety envelope for the safety assurance program for the waste processing alternative chosen for implementation. Subsequent programs such as the development of technical safety requirements, environmental safety and health programs, and safety analysis reports provide the protective features that ensure that safety is not compromised. The EIS facility accident analysis scope encompasses the limits of safety concerns for the future facilities needed to implement waste processing alternatives. At the time these facilities are designed, built, and operated, the safety documentation needed to maintain safety assurance at these facilities would use information in the TRD to bound concerns as well as to focus assessments and commitments. Safety analysis reports and safety analysis reports for packaging do not define new areas of concern but represent scenarios that are contained within the set of accidents outlined in this EIS. The EIS facility analysis scope as compared to future safety documentation is shown in Figure C.4-3.

The scope of this appendix and the TRD involves identification of a set of bounding accidents for HLW management and determination of source terms for each selected bounding event. Specific accident analysis information includes the following:

- Identification of the potential for significant accidents in activities, operations, and facilities (process elements) associated with each alternative

- Definition of a set of discrete evaluations that comprehensively assess accidents for each process element and are used to establish a set of bounding accidents for each alternative

- Performance of comprehensive, technically rigorous, and consistent analysis of abnormal, design basis, and beyond design basis accidents for each process element

- Identification of bounding abnormal, design basis, and beyond design basis accidents for each process element

- Development of source terms and the basis for estimating source terms for the bounding accidents

The TRD provides input information to a consequence assessment that, in turn, provides estimated doses and health consequences to individuals and exposed populations. These results are presented in this appendix and Section 5.2.14. This relationship is shown in Figure C.4-4. The scopes of this appendix and the TRD do not include:

- Evaluation of facility accidents occurring at sites other than INEEL

- Evaluation of accidents associated with transportation of radioactive or hazardous material, other than transportation within a site as part of facility operations

- Evaluation of environmental impacts (Human health impacts are the primary focus rather than flora of fauna impacts. If significant environmental impacts had been identified, they would have been evaluated)

- Evaluation of facility closure accidents, which are included in Section C.4.2 of this appendix and Section 5.3.11 of the Idaho HLW & FD EIS

The process of identifying potentially bounding accidents and source terms (the output of the *Technical Resource Document*) is initiated with screening evaluations to determine activities to implement waste processing alternatives that could result in bounding accidents. In addition, the process includes identification of accident scenarios, development of frequencies for accident scenarios, development of source terms for accident scenarios, and selection of potentially bounding accident scenarios for consequence evaluation. The relationship of TRD elements and references to the produced results is shown in Figure C.4-5.

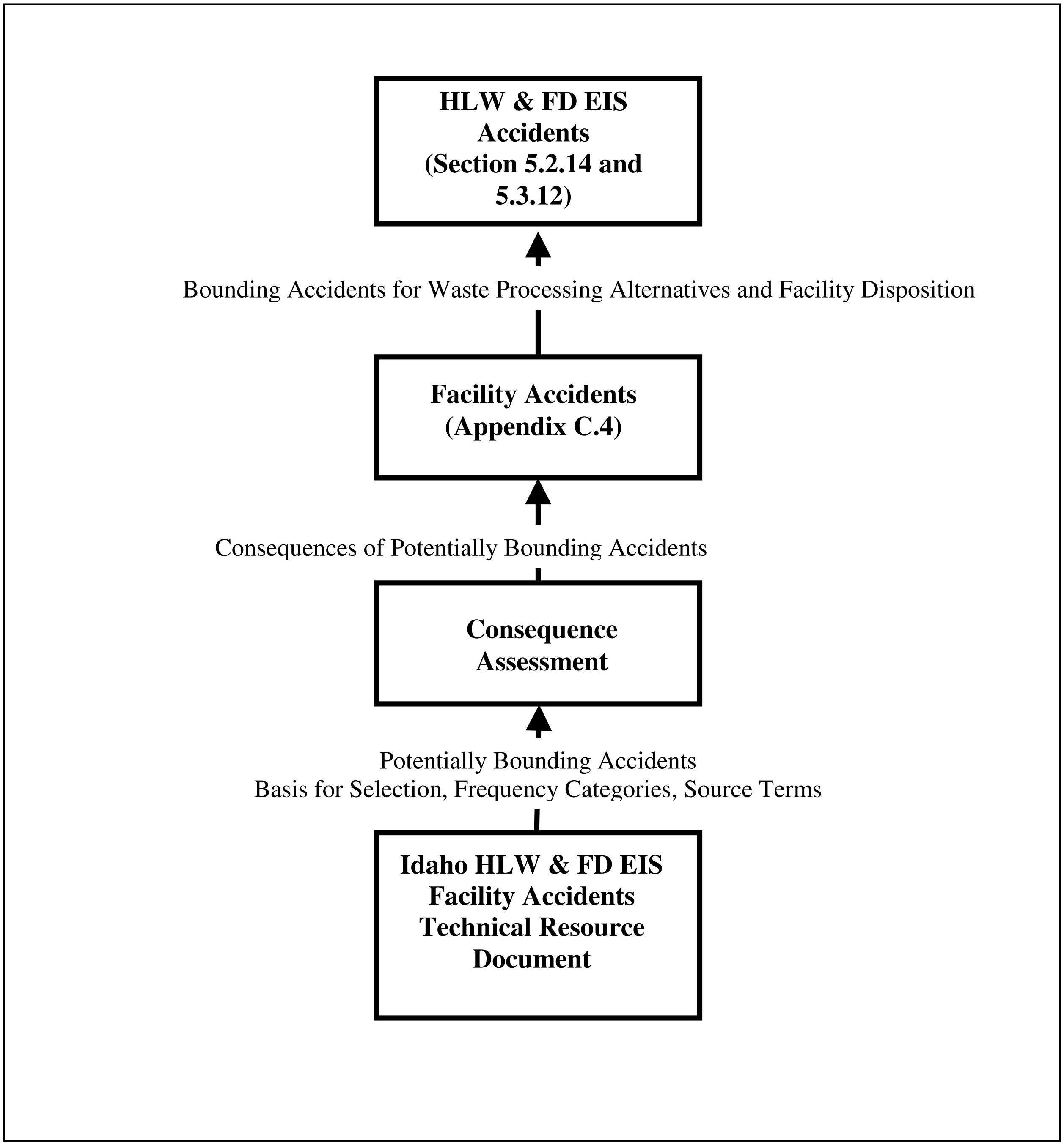

Figure C.4-4. Facility Accidents Technical Resource Document as reference document.

C.4.1.1.3 Overview of Facility Accidents Analysis

Section C.4.1.2 describes the methodology or technical approach used to identify and evaluate bounding accidents for each waste processing alternative and identifies the alternatives and their risk-contributing attributes that are considered in the accident analysis. Also, Section C.4.1.2 identifies six generic types of accidents, the two types of source terms, (i.e., radiological and hazardous material releases), the sources of the material/mass balance data for generating the source terms, and a discussion of natural phenomena/external events that could initiate accidents. This latter discussion provides the basis for predicting the frequency of natural phenomena, which are key initiators of potentially bounding accidents for waste processing alternatives. External events, or operational failures occurring outside a facility, may impact the safety and operability of the facility. This section discusses the basis for screening potential external event causes at INTEC and a systematic approach to establishing completeness for the review process. Section C.4.1.2.5 provides an evaluation of involved worker risk that can result from industrial accidents, exposure to radioactive materials during normal operations, and facility accidents. Risk from occupational exposures and industrial accidents is appraised in Appendix C.3. The accident analysis evaluations do not directly provide the portion of risk posed by bounding facility accident scenarios for an alternative. However, a heuristic argument is developed.

Section C.4.1.3 describes the results of a multi-level screening process that has been used to identify and evaluate bounding radioactive-release accidents for the process elements of the waste processing alternatives. Results of the top-level screening evaluation (C.4.1.3.1) are used to prioritize the processes or major facilities that are associated with implementing the alternatives. The prioritization process is used to define a minimum set of accident evaluations that provide a sufficiently comprehensive basis for identifying bounding accidents. Results of the second-level screening process, the accident evaluations, are summarized in descriptions of the bounding accidents for each of the accident evaluations in Sections C.4.1.3.2 through C.4.1.3.4. Results are presented so that the waste processing alternatives to which they apply are clearly identified. Consistent with DOE recommendations for National Environmental Policy Act accident analysis, bounding accidents are identified for three frequency ranges: abnormal events occurring at least once in a thousand years of facility operation (frequency $\geq 1.0\times10^{-3}$ per year); design basis events occurring between once in a thousand and once in a million years of operation (1.0×10^{-3} > frequency $\geq 1.0\times10^{-6}$ per year); and beyond design basis events occurring less frequently than once in a million years of facility operation but equal to or greater than once in ten million years (1.0×10^{-6} > frequency $\geq 1.0\times10^{-7}$ per year). Each accident evaluation summary provides the basis for frequency range categorization and the makeup of source term releases that would occur.

Section C.4.1.4 describes accident analysis that could result in release of hazardous chemicals. Chemical release accidents may have a direct impact on the public or may initiate a cascade of onsite events that eventually result in a release of radioactive materials. Results of the process element screening process are given, and the results of the accident evaluations for potentially significant releases of chemical substances are expressed for each frequency range in postulated source terms in Sections C.4.1.4.2 through C.4.1.4.4.

Section C.4.1.5 describes the consequences of the various accident analyses. Consequences represent radiological impacts to INEEL workers and the general public (C.4.1.5.1). Accidents that contribute chemicals to the atmosphere during the event are discussed in Section C.4.1.5.2. Accidents that produce mainly groundwater releases are discussed in Section C.4.1.5.3.

Section C.4.1.6 provides the results of the point estimates of involved worker risk and the mean values of the simulations and provides the relative contributions from industrial accidents, facility accidents, and occupational exposure.

Section C.4.1.7 provides a basis for identifying a bounding accident in each of the three frequency categories for each waste processing alternative. In particular, the section provides a crosswalk between significant accidents described in Section C.4.1.3 and the waste processing alternatives, as well as a rationale for identifying the bounding accidents for each frequency category. Also, Section C.4.1.7 includes a discussion of groundwater releases, localized hazards, common cause initiators and a sensitivity analysis of the consequences. Section C.4.1.7.6 provides an integrated perspective on risk to co-located workers and the public as a result of bounding facility accidents for all waste processing alternatives. The contributed risk of bounding accidents is compared with guidelines for design and operation of DOE facilities.

Section C.4.2 summarizes the facility disposition analysis that was conducted to evaluate the disposition of the major HLW facilities and to assess the relative impacts of each planned facility disposition with respect to potential facility accidents.

Section C.4.2.1 provides a discussion of the purpose of the facility disposition section and the approach and scope of the analyses for both noninvolved workers and the offsite public and the involved worker.

Section C.4.2.2 describes the three facility disposition alternatives considered by DOE in this EIS. These alternatives include clean closure, performance-based closure, and closure to landfill standards.

Sections C.4.2.3 and C.4.2.4 outline the analysis methodology used for noninvolved workers and the offsite population and the involved worker, respectively.

C.4.1.2 Methodology

C.4.1.2.1 Basis For Selection of Potentially Bounding Accidents

The technical approach and methods used in this analysis are intended to be fully compliant with DOE technical guidelines for accident analysis (DOE 1993b). These same guidelines allow the exclusion of information that is previously addressed in other EIS documents. For activities occurring at Hanford under the Minimum INEEL Processing Alternative, facility accidents due to the processing of INEEL waste are effectively analyzed in the Jacobs Engineering evaluation (Jacobs 1998) that is based on information from the Tank Waste Remediation System (TWRS) EIS (DOE 1998a). Accidents that could occur during the processing of INEEL waste are bounded by accidents that are defined for the TWRS waste treatment alternatives. Another similar example of partitioning in this EIS is the exclusion of the accidents at WIPP from predicted impacts. Such exclusions are not only permissible in DOE NEPA guidelines, they constitute a reasonable method of assuring that there is not a "double counting" of impacts associated with DOE activities. Technical guidelines require the identification of accidents for each alternative that are reasonably foreseeable and bounding. A bounding accident is defined as the reasonably foreseeable event that has the highest potential for environmental impacts, particularly human health and safety impacts, among all reasonably foreseeable accidents.

Most of the facilities and operations comprising the major waste processing alternatives do not as yet have specified design criteria. For the TRD, the term "reasonably foreseeable" is defined as the combined probability and consequences of accident events to include those scenarios with the potential for contributing a human health risk of once in 10 million years or greater. An accident that occurs with a frequency of once in 10 million years and would likely result in one or more fatalities is reasonably foreseeable. Bounding accidents are identified in three frequency ranges of occurrence:

- **Abnormal Events –** occur at a frequency equal to or greater than once in a thousand years.
- **Design Basis Events –** occur at a frequency equal to or greater than once in a million years but less than once in a thousand years.
- **Beyond Design Basis Events –** occur at a frequency equal to or greater than once in 10 million years but less than once in a million years.

Accident analysis of HLW treatment facilities that are currently operating has been performed using data from facility safety assurance documentation, facility operating experience, and probabilistic data from similar facilities and operations. Accident analysis of facilities that have not as yet been designed relies mainly on information from technical feasibility studies that establish basic design parameters and process implementation costs. Information used in the accident analysis includes preliminary facility inventories, material at risk for major process streams within a facility, process design data, and some overall design features. Considering the early state of knowledge on most facility designs, methods used to assess the potential for facility accidents are based mainly on DOE guidance, experience with similar systems, and an understanding of the INTEC site layout. Documents such as safety analysis reports, safety reviews, and unresolved safety question determinations that routinely evaluate the potential for harm to human health have not been available for this EIS accident analysis.

The Idaho HLW & FD EIS accident analysis (developed in the TRD) for HLW treatment facilities incorporates three levels of screening analyses:

1. A screening evaluation of major facilities and operations (process elements) needed to implement waste processing alternatives has been performed to assess the potential for significant facility accidents. The accident potential of various process elements has been evaluated and prioritized. Process element attributes that infer the existence of significant process hazards include inventories of hazardous or radioactive materials, dispersible physical forms, and the potential for energetic releases during operation. Therefore, the existence of significant hazards in facility operation is a prerequisite for potentially bounding accidents. Table C.4-2 describes the basis for selecting process elements for further review. Process elements with a moderate potential for accidents are selected for detailed accident analysis.

2. Detailed accident analysis begins with the description of activities, inventories, and conditions pertinent to the accident analysis. A standardized set of "accident initiating events" is compared against the described set of activities, inventories, and operating conditions to identify and describe "accident scenarios." Accident initiating events are those with varying frequency and severity that challenge and sometimes degrade the safety functions of the facility. The six categories of initiators used in the accident analysis include:

   – Failures resulting in fires during facility operations

   – Failures resulting in explosions during facility operations

Table C.4-2. Accident analysis evaluation prioritization basis.

Prioritization basis for process elements	Activity not likely to yield bounding accident scenarios[a,b,c]	Activity may yield bounding accident scenarios[a,b,c]	Activity likely to yield bounding accident scenarios[a,b,c]
Previous EIS or SARs[d] provide sufficient data to evaluate accident potential[e,g]	IIIA	IIA	IA
Previous EIS or SARs provide portion of data to evaluate accident potential[f,g]	IIIB	IIB	IB
Previous EIS or SARs do not provide data to evaluate accident potential[f,h]	IIIC	IIC	IC

a. EIS guidelines on accident analysis define sets of occurrences that "bound" the potential for accidents during facility operation to impact the environment are identified for each treatment alternative. A scenario is bounding if it is a credible event that results in the most impact.

b. EIS guidelines require that bounding accidents be identified for process elements that implement an alternative in three frequency ranges:
- Abnormal events occurring at a frequency $\geq 1.0\times10^{-3}$ per year,
- Design Basis events occurring at a frequency of $< 1.0\times10^{-3}$ per year and $\geq 1.0\times10^{-6}$ per year, and
- Beyond Design Basis events occurring $< 1.0\times10^{-6}$ per year but $\geq 1.0\times10^{-7}$ per year.

c. Priority rankings for process element accident potential are as follows:
   I. Inventory at risk and frequency of accidental release are likely to produce bounding accident for treatment alternative,
   II. Inventory at risk and frequency of accidental release could credibly produce a bounding accident scenario.
   III. Process element does not contain sufficient inventory or driving release energy to result in bounding scenario.

d. SAR = Safety Analysis Report.

e. Previously completed evaluations on this or an equivalent facility provide a sufficient data to identify accident scenarios, identify inventories of materials at risk, accident scenario frequencies of occurrence, and accident scenario release fractions.

f. Priority rankings for available data sources are as follows:
   A. Sufficient data already exists to support accident evaluation for waste processing alternatives.
   B. Data may be extrapolated from previous evaluations, supplemented by systems reviews.
   C. Current information sources are inadequate. Data must be supplied through systems reviews.

g. Previously completed evaluations on this or similar facilities could provide part of the information needed to identify accident scenarios, frequencies of occurrence, and source terms. Existing documentation would have to be supplemented with independent systematic reviews to provide a consistent and viable accident analysis basis.

h. Due to uncertainties regarding the technology or its application to a process element, existing documents do not provide information needed to identify accident scenarios, frequencies of occurrence, and source terms. Systematic reviews are required to evaluate accident potential.

(shaded)	Requires accident analysis evaluation that includes systematic scenario identification, estimation of accident frequencies, identification of bounding accidents, and estimation of source terms.
(unshaded)	Does not require accident evaluation based on currently available information.

- Failures resulting in inventory spills
- Operational failures resulting in occurrence of criticality
- Occurrence of natural phenomena (such as seismic events or floods) that induce damage to a facility and require safe shutdown
- Occurrence of external events (usually human-initiated events not occurring in a facility)

An accident scenario consists of a set of causal events starting with an initiating event that can lead to release of radioactive or hazardous materials with the potential to cause injury or death.

3. Finally, accident scenarios are "binned" into the three major frequency categories, and the accident scenario in each frequency range with the highest potential risk of health and safety impacts to offsite persons or co-located onsite workers (the dominant accident scenario) is selected for evaluation of source terms and human health consequences. Sources of initiator frequencies include DOE guidelines and reports [(i.e., DOE-STD-1021 (DOE 1996a) and DOE-STD-1024 (DOE 1996b) for natural phenomena)], NRC guidelines and reports, and commercial sources of accident and reliability data. Source terms for each of the dominant accident scenarios are estimated. Source terms of dominant accident scenarios associated with each alternative in each frequency range are compared, and the scenario with the largest risk implications is chosen for reporting in Section 5.2.14, Facility Accidents.

C.4.1.2.2 Bounding Accident Scenarios

Systems Review Team

A team of systems review analysts was selected to evaluate potential accidents that could arise from operation of the identified facilities and activities. The team was comprised of individuals from DOE-ID and other organizations. The team included personnel knowledgeable in HLW management, facility operation, radiological hazards, chemical hazards, hazards identification, source term development, and consequence evaluation. The analysis team was subdivided into two groups. One group developed the accident evaluation methodology and conducted the accident evaluations. The other group provided project oversight and review of documents prepared by the methodology group.

Systems Review Methodology

The ultimate objective in the systems review process was the determination of bounding accident scenarios for each activity. However, DOE also tried to capture and retain the work that went into the intermediate steps in the process. To ensure traceability of how the bounding accidents were selected and how the source terms were estimated, detailed documentation for each of the 24 process elements was incorporated in Appendix A of the TRD. Table C.4-3 provides the form used to document the accident identification process for each of the 24 process elements. The actual forms for each process element are provided in the TRD. Section C.4.1.2.3 describes how the source terms were selected.

Bounding Accident Scenario Identification (Per Table C.4-3)

Process/Alternative Data. The information in this block is related to operations data (e.g., Primary Activities and Operating Information) for the process elements and radioactive or hazardous material inventory information (e.g., Material Inventories) for the alternatives. Since this form serves as a summary sheet, the information in this block is not intended to be an exhaustive listing of every detail of the process/alternative, but should provide sufficient data to validate and understand the results of the bounding accident analysis.

Hazards Identification. This section is structured as a table showing the accident type with respect to accident frequency range. The six accident types included in this section were outlined above and are fire, explosion, spill, criticality, natural phenomena, and external events. The three frequency ranges, abnormal, design basis, and beyond design basis, are based on the definitions in Section C.4.1.2.1. This hazards identification table identifies all the reasonably foreseeable accidents for each accident type and frequency range and shows the "bounding accident" in italics. These accidents are based on different release mechanisms. This approach lends itself to the source term development process since the source terms are a function of the release mechanism. It is noted that natural phenomena and external events are provided as separate accident types, even though they are merely additional causes for the other four accident types (e.g., an earthquake causes a spill). This is done for completeness to ensure that these types of events, which are often overlooked, are evaluated. In addition, there may be cases where an accident could logically fit into two accident types. For instance, an explosion could topple a drum and result in a spill. The exact placement of the scenario is not important, just that it is captured in the table. Sabotage and terrorist activities maybe classified as either internal or external initiators but will not be addressed separately. It was believed that sabotage or terrorist activities are just a mechanism to cause one of the accident types already presented. Sabotage and terrorism are not random or accidental events but the consequences from these acts are likely bounded by events already defined as accidents.

Table C.4-3. Accident Analysis Summary Form

SUMMARY SHEET ***PROCESS ELEMENT*** **(Table 1.3, Accident Analysis #)**			
Alternative/ Option(s)			
PROCESS/ALTERNATIVE DATA			
Primary Activities			
Material Inventories			
Operating Information			
HAZARDS IDENTIFICATION			
	Frequency Bins		
Accident Type	**Abnormal**	**Design Basis Event**	**Beyond Design Basis**
Fire			
Explosion			
Spill			
Criticality			
Natural Phenomena: flood, lightning, seismic, high wind			
External Events			
ACCIDENT SCENARIO DESCRIPTIONS			
Identifier	Description		
Abnormal Event *Justification for selection of bounding Abnormal Event.*			
Design Basis Event *Justification for selection of bounding Design Basis Event*			
Beyond Design Basis Event *Justification for selection of bounding Beyond Design Basis Event*			
REFERENCES			

Nominally, each of the cells in the Hazard Identification Table is populated with a brief description of a reasonable worst-case scenario for each frequency bin and accident type. An exception would be processes/alternatives, which involve both chemicals and radioactive materials. In these cases, a chemical accident scenario and a radiological accident scenario are identified. It is recognized that there are some accident types/frequency combinations that will be left blank since there isn't a logical accident scenario that would fit in the cell.

Accident Scenario Descriptions. This section shows more detailed descriptions of all the potential accidents identified in the Hazardous Identification Table just discussed. These scenario descriptions include additional information such as data on the material at risk, material form, and pertinent information to determine the source term. Also, this section shows the bounding accident in italics and a justification for the choice of the bounding accident.

Evaluating the Potential Impact of Additional Information on Bounding Accidents

Over time, additional information may become available that raises concerns over the choice of bounding facility accidents or the potential consequences of such accidents. Such additional information might include:

- Vulnerabilities not previously recognized in the systematic accident analysis contained within the TRD (e.g., the impact of newly received engineering data modifying the expected response of a system to one or more external natural phenomena)

- Proposed projects not included in the affected environment baseline that could impact the perception of stakeholders and reviewers regarding the adequacy and comprehensiveness of the Idaho HLW & FD EIS (e.g., the potential impact of locating the Venture Star ground support operation at INEEL)

Additional information must be evaluated efficiently and the results reflected in the Idaho HLW & FD EIS Project File. A rapid approach can be used to evaluate additional information using a risk-based perturbation process. In this perturbation process, risks associated with current bounding accidents are estimated and used as a risk baseline. Changes in the baseline risk data as a result of new unanalyzed information are reflected as modifications to the baseline risk projections. Appendix C of the TRD provides a detailed explanation of the use of this risk-based perturbation process.

Of the accident scenarios identified in Appendix A of the TRD, 72 accidents were selected as being potentially bounding based on the probabilistic and source term information developed. Of the

72 accidents reported in the TRD, 27 accidents (one abnormal event, one design basis event, and one beyond design basis event accident for each of the nine waste processing alternatives) were identified as being bounding based on evaluation of consequences. Health consequences were evaluated as a result of exposure to released radioactive materials and/or released chemically toxic substances. Consequences of radioactive material exposures were calculated for a hypothetical maximally exposed individual (in rem) at the closest publicly accessible point to the release, a hypothetical non-involved worker (in rem) who is onsite and located 640 meters from the accident, and the offsite population within a 50-mile range (in person-rem) of radiation dose to the general public for doses less than 20 rem. For larger doses, when the rate of exposure would be greater than 10 rad (radiation absorbed dose) per hour, the increased likelihood of latent cancer fatality is doubled, assuming the body's diminished capability to repair radiation damage. For offsite consequences, the number of expected fatalities of the exposed population was estimated using the currently accepted mortality factor of 5.0×10^{-4} latent cancer fatalities per person-rem. Frequencies for each accident (per year of operation) were estimated using:

- Design data and other information on waste processing alternatives and natural phenomena
- Knowledge of systems vulnerabilities for critical HLW treatment systems based on extrapolation of data from similar previously evaluated systems
- Site-specific evaluations performed during the Idaho HLW & FD EIS preparation

C.4.1.2.3 Source Term Review Basis

Source Term Review Methodology

Source terms were developed for each of the bounding accidents identified for the 24 process elements or activities that were evaluated for each of the three frequency bins. Although the accidents involved different initiators and material forms, there were two distinct source term types that were considered: radiological releases and chemical releases. The following paragraphs describe these two distinct source terms types.

Radiological Releases

For non-criticality radiological releases, the source term is defined as the amount of respirable material that is released to the atmosphere from a specific location. The radiological source term for non-criticality events is dependent upon several factors including the material at risk, material form, initiator, operating conditions, and material composition. This relationship is summarized in the equation given below, which is modified from the *Safety Analysis and Risk Assessment Handbook* (Peterson 1997) and in DOE-STD-3010) (DOE 1994). The technical approach described in DOE-STD-3010 is used to estimate source terms for radioactive releases. This approach applies a linear set of release factors to the material at risk constituents to produce an estimated release inventory. The release inventory is combined with the conditions under which the release occurs and other environmental factors to produce the total material released (Q) for consequence estimation. Factors applied in the DOE-STD-3010 source term method are shown below (DOE 1994).

$$Q = MAR \times DR \times LPF \times ARF \times RF \times COMP$$

Where:

Q	=	Total Material Released (Ci)
MAR	=	Material At Risk (Ci, volume, or mass based on inventories or process flow rates)
DR	=	Damage Ratio (fraction of the material at risk that is exposed to the event)
LPF	=	Leakpath Factor (fraction of the material that enters the outdoor environment)
ARF	=	Airborne Release Fraction (fraction of material released suspended in air)
RF	=	Respirable Fraction (fraction of material released that can be inhaled)
COMP	=	Material Composition by Radionuclide (Ci, Ci/volume, or Ci/mass)

For criticality events, the source term also includes exposure to prompt critical radiation, which is a function of the number of fissions involved. The number of fissions is dependent upon the nuclear material orientation and type. Criticality is assessed internally in each accident analysis. Only one bounding criticality accident scenario was identified. DBE 21, Transuranic Waste Stabilization and Preparation for Transport to the Waste Isolation Pilot Plant, identified an inadvertent criticality during transuranic waste shipping container loading operations as a result of vulnerability to loss of control over storage geometry. This scenario is identified in Table 3.4-11 under the Minimum INEEL Processing Alternative. Most waste processing alternatives would not contribute enough fissile materials in an aqueous environment to allow criticalities to develop.

Chemical Releases

Chemicals that pose the greatest hazard to workers and the public are gases at ambient temperature and pressure. An example is ammonia, which is stored under pressure as a liquid but quickly becomes a vapor as it is released. Chemicals such as nitric acid are liquids at ambient conditions and pose a toxic hazard to involved workers. However, the potential for these types of chemicals to become airborne and travel to co-located or offsite facilities is low. Therefore, the focus of the chemical hazards is on those chemicals that are gases at ambient conditions.

Technically, the release mechanism of pressurized gases involves a fraction that becomes vapor as the gas depressurizes and a fraction that drops to the ground and forms a boiling pool. The pool-boiling rate is a function of several factors: pool area; the type of substrate material (e.g., soil, concrete, etc.); and the substrate temperature. Another factor that influences the gaseous release is the degree to which liquid droplets became entrained into the flash fraction.

Rather than quantifying each of these factors, an alternate approach was taken based on guidance in the U.S. Environmental Protection Agency's *Technical Guidance for Hazards Analysis* (EPA 1987). In that document, it was recommended that the material at risk be released over a 10-minute duration. This was the approach taken for leaks from process vessels, as well as catastrophic failures of process vessels. However, for scenarios that involve fires that do not directly consume the hazardous chemical, the material at risk was assumed to be released over a 1-minute duration. This is to account for the significant energy driver from the fire that would influence the rate of release.

In addition to being a direct toxic hazard to workers and the public, chemical releases also serve as indirect, external initiators for radiological releases. This release could occur in processes that require significant operator attention and where operator incapacitation could lead to other accidents. Consideration of chemical releases as external events is treated on a case-by-case basis for each alternative activity.

Source Term Identification

As is the case for the selection of the bounding accidents for each of the 24 process elements, Appendix A of DOE (1998a) presents the documentation that supports the source term identification or estimation for the same process elements. The following Table C.4-4 shows the estimation process that was used for the AA01 (New Waste Calcining Facility Continued Operations) source terms; the following paragraph explains the elements of Table C.4-4.

- **Bounding Event.** This section presents the Accident Description, Material Form, Release Mechanism (Initiator), and Rationale for Selection for the bounding event.

Table C.4-4. Source term data for AA01 (example only).

Abnormal event	
Process element	New Waste Calcining Facility Continued Operation
Accident description	The bounding accident was chosen to be a fuel fire in the calciner cell. A kerosene spill due to a failed fuel line could ignite due to the high temperature environment. The equipment in the calciner cell will not be impacted since it was designed to withstand the consequences of a cell fire. However, the products of combustion from a fire could degrade the HEPA filters in the ventilation system and release accumulated radionuclides.
Material form	Material accumulated on HEPA filters.
Release mechanism	Fire. The heat released from the fire is transferred through the heating, ventilation, and air conditioning exhaust duct where the heat flows through the HEPA filters. The heat degrades the heating, ventilation, and air conditioning exhaust filter media releasing the radionuclides.
Rationale for selection	Represents bounding scenario in the "abnormal" frequency range.

Input data		
Parameter	Value	Comment
Available material at risk	See Table 1	The New Waste Calcining Facility Safety Analysis Report, Table 3-9, provides an estimate of the activity on the HEPA filter. This estimate is based on analyses of samples from the Tank Farm SBW from tanks WM-180 and WM-181.
Key radiological components	See Table 1	The New Waste Calcining Facility Safety Analysis Report, Table 3-9, provides an estimate of the activity on the HEPA filter. This estimate is based on analyses of samples from the Tank Farm SBW from tanks WM-180 and WM-181.
Damage ratio	1.0	Bounding value.
Leak path factor	1.0	Bounding value. HEPA filters are assumed to be impacted by scenario and provide no filtration.
Airborne release fraction	1.0×10^{-4}	Per DOE-STD-3010, airborne release fraction applicable for fires impacting HEPA filter contamination.
Respirable fraction	1.0	Per DOE-STD-3010, respirable fraction applicable for fires impacting HEPA filter contamination.
Total material released	See Table 1	The source term is tabulated below.

Isotopic Source Term for New Waste Calcining Facility heating, ventilation, and air conditioning (activity taken from New Waste Calcining Facility Safety Analysis Report Table 3-9)

Isotope	Activity (curies)	Airborne release fraction	Source term (curies)
Am-241	3.5×10^{-3}	1.0×10^{-4}	7.0×10^{-7}
Ba-137m	1.7	1.0×10^{-4}	3.4×10^{-4}
Co-60	0.01	1.0×10^{-4}	2.2×10^{-6}
Cs-134	0.07	1.0×10^{-4}	1.3×10^{-5}
Cs-137	1.8	1.0×10^{-4}	3.6×10^{-4}
Eu-154	0.03	1.0×10^{-4}	5.4×10^{-6}
Eu-155	9.7×10^{-3}	1.0×10^{-4}	1.9×10^{-6}
Pu-238	0.04	1.0×10^{-4}	8.0×10^{-6}
Pu-239	5.9×10^{-3}	1.0×10^{-4}	1.2×10^{-6}
Sb-125	0.02	1.0×10^{-4}	3.2×10^{-6}
Sr-90	1.7	1.0×10^{-4}	3.4×10^{-4}
Y-90	1.7	1.0×10^{-4}	3.4×10^{-4}

- **Input Data.** This section of the table show the input data necessary to calculate the source term (i.e., Available Material at Risk, Key Radiological Components, Damage Ratio, Leak Path Factor, Airborne Release Fraction, Respirable Fraction, and the estimated Total Material Released).

- **Source Term Table.** Table shows all the nuclear isotopes and the associated source terms in curies.

Qualification of Facilities Inventories and Materials at Risk

DOE must identify the optimal source of material/mass balance data for use in generating the source terms from the material at risk values derived during the accident analysis review. In accordance with the Idaho HLW & FD EIS Notice of Intent, the accident analysis team has relied upon existing documents and made use of previously developed information and analyses. On this basis, the accident analysis team developed source terms that support accident evaluation scenarios using information taken from approved references.

During late 1997, D. R. Wenzel, at INTEC, was requested to prepare engineering design files that evaluated the radionuclide inventories associated with zirconium calcine, aluminum calcine, and SBW (Wenzel 1997a,b). At approximately this same time, Fluor Daniel, Inc. was contracted to develop a feasibility studies report that evaluated the potential HLW treatment facilities being considered under the Separations Alternative. However, circumstances prevented Fluor Daniel, Inc. from utilizing the D. R. Wenzel data as part of their references for use in their report.

The designs presented in the Fluor Daniel Study (Fluor Daniel 1997) are based on material balances and flowsheets provided in Barnes et al. (1997). The Fluor Daniel study assumed that the waste characterization data in Barnes et al. (1997) was reasonably accurate and it was assumed that no unknown condition would be identified.

The Wenzel data was generated in October 1997, nearly 6 months after the Barnes data was collected (Wenzel 1997a,b). Wenzel developed Engineering Design Files for aluminum and zirconium calcine and SBW but did not evaluate the isotopic concentrations associated with the various treatment processes included in the Idaho HLW & FD EIS. The Wenzel data provides weighted averages of the radionuclide inventories in all SBW tanks. It also provides the inventory of bin set #1 (aluminum calcine waste) and a composite of the zirconium calcine waste in the other bin sets.

To this end, the radionuclide inventory generated by Wenzel for aluminum and zirconium calcine and SBW (decayed until 2016) was compared against the Fluor Daniel inventory. Table C.4-5 is a summary of this comparison. The ratios of the doses that result from comparison of the two data sets are presented in Tables C.4-6 and C.4-7. Table C.4-6 compares the ratios of the doses resulting from the Fluor Daniel data (undecayed) to the Wenzel data. From these ratios it is apparent that the Fluor Daniel data results in higher doses than the Wenzel data; these ratios range from a factor of 6.00 to 1.52 higher. Table C.4-7 compares the ratio of the doses resulting from the Fluor Daniel data (decayed to 2016) to the Wenzel data. Again the Fluor Daniel data results in doses that are higher by a factor of 4.7 to 1.1.

Table C.4-5. Fluor-Daniel versus Wenzel data.

Scenario	Maximally-exposed individual dose (millirem)	Non-involved worker dose (millirem)	Population dose (person-rem)	Latent cancer fatalities
ABN 03	18	1.2×10^{3}	220	0.11
ABN 03D[a]	14	940	150	0.07
ABN 03W[b]	3	210	110	0.06
DBD 03	460	3.2×10^{4}	4.1×10^{3}	2.1
DBD 03D	370	2.5×10^{4}	2.9×10^{3}	1.5
DBD 03W	270	1.9×10^{4}	2.6×10^{3}	1.3
ABN 24	6.4×10^{-3}	0.43	0.08	4.1×10^{-5}
ABN 24D	5.3×10^{-3}	0.36	0.06	2.8×10^{-5}
ABN 24W	4.2×10^{-3}	0.28	0.04	2.2×10^{-5}

a. D signifies Fluor-Daniel numbers decayed to the year 2016 consistent with Wenzel values.
b. W signifies using the Wenzel concentrations in the year 2016.

Table C.4-6. Ratio of Fluor-Daniel (undecayed) versus Wenzel dose values.

Scenario		Maximally-exposed individual dose ratio	Non-involved worker dose ratio	Population dose ratio	Latent cancer fatalities ratio
Aluminum calcine	D/W ratio	6.0	5.7	2.0	2.0
Zirconium calcine	D/W ratio	1.7	1.7	1.6	1.6
SBW	D/W ratio	1.5	1.5	1.9	1.8

Table C.4-7. Ratio of Fluor-Daniel (decayed) versus Wenzel dose values.

Scenario		Maximally-exposed individual dose ratio	Non-involved worker dose ratio	Population dose ratio	Latent cancer fatalities ratio
Aluminum calcine	D/W ratio	4.7	4.5	1.4	1.2
Zirconium calcine	D/W ratio	1.7	1.3	1.1	1.2
SBW	D/W ratio	1.3	1.3	1.5	1.3

From the data presented in Tables C.4-6 and C.4-7, it becomes clear that the doses resulting from the use of the Wenzel data are bounded by the doses resulting from the use of the Fluor Daniel data. Thus, the accident analysis team could use the Fluor Daniel data for the development of the various accident source terms based on the material at risks they developed. The outcome of using the Fluor Daniel data will result in doses that are conservative.

C.4.1.2.4 Natural Phenomena/External Events

A number of natural phenomena and external events could potentially impact the site and result in releases of radiological and/or chemical inventories. For natural phenomena hazards, DOE-STD-1021 has established performance categorization guidelines for structures, systems, and components (DOE 1996a). The rating system is out of a scale from one (PC-1) to four (PC-4) with four being the most restrictive. However, the PC-4 categorization is reserved for facilities that could result in offsite release consequences greater than or equal to the unmitigated release from a large (>20 MW) Category A reactor accident. The INEEL facilities do pose potential adverse release consequences but do not fall within the definition of a PC-4 facility. Therefore, most INEEL HLW facilities are classified as PC-3.

Per DOE-STD-1020, PC-3 structures, systems, and components are assigned mean annual probabilities of exceeding acceptable behavior limits of 1.0×10^{-4} per year (DOE 1996c). The natural phenomena evaluations in this analysis are linked to the design criteria associated with the 10,000-year event (1.0×10^{-4} per year). Since the structures, systems, and components are to be designed to these criteria, they are not anticipated to fail until a larger magnitude-initiating event with a lower frequency ($<1.0\times10^{-4}$ per year) occurs. Even with larger magnitude initiating events, there is still only a conditional probability (e.g., fragility curves for seismic evaluations) that a structure, system, or component will fail. However, these conditional probabilities vary with the types of initiators and are also dependent upon specific design details of the structure, system, or components. Although this approach may appear overly conservative from a frequency standpoint, there may be no impact from a relative frequency standpoint. The following paragraphs define the frequency ranges assigned to various natural phenomena in this EIS.

Range Fire

A range fire can result in loss of offsite power that, in turn, results in loss of ventilation to the facility and a slow release. Range fires have occurred on or in the vicinity of the INEEL during 1994, 1995, and 1996. While a range fire would not endanger the process element under consideration, due to defoliated zones, facility fence, etc., smoke from the fire could require personnel evacuation and disrupt operations. However, the most severe consequence of a range fire would be a loss of offsite power due to firedamaged transmission lines. Loss of offsite power could result in a loss of zoned building ventilation which, could result in a slow loss of material confinement. Loss of building confinement would create leakage pathways through doorways, airlocks, loading docks, and other building access points. The consequences associated with a range fire are anticipated to be minimal and in most cases would be bounded by operational events such as an electrical panel/motor fire. Unless specific design features of the process element warrant a lower frequency, range fires are generally placed in the abnormal event frequency bin.

Design Basis Seismic Event

A design basis event seismic event can cause failure of the facility structure and/or equipment such that a release occurs with a pathway to the environment. The design basis event seismic scenario frequency is dominated by failure of bin set #1 since its seismically induced failure frequency (5.0×10^{-3} per year) is substantially greater than that of the other six bin sets (5.0×10^{-5} per year). The frequency 5.0×10^{-3} per year was assumed for bin set #1 since the DOE-STD-1021 prescribes that Category 3 facilities withstand a 1.0×10^{-4} per year earthquake (DOE 1996a). Bin set #1 does not meet this standard and its probabilistic performance has been degraded by a factor 5. So instead of a 10,000 year earthquake failing bin set #1, it will fail at a 2,000 year return period.

Analysis of design basis event seismic initiators in the TRD imply that under severe seismic loading one bin set may fail catastrophically. A question has been raised as to why only one bin set can fail, and not the other six bin sets. Failure of bin sets #2 to #7 is considered a design basis event as shown above. Given the well-known “fragility” curve, although a failure could occur at a specific seismic level, it probably will not. Thus, seismicity as a common cause source for failures does not prevent one unit failing and the others not. In fact, reviews of seismic damage to commercial facilities routinely reveal one specific component failing while all others, more or less with the same loading, do not. Thus, it would be overly conservative to assume “complete coupling” in seismic failures of multiple bin sets.

Flood-Induced Failure

A major flood can cause damage to the facility structure and subsequent equipment failures, thereby causing a release of materials from the facility to the environment. In particular, bin set #1 has been determined, by analysis, to be statically unstable. Under flood conditions, the berm surrounding bin set #1 could be undermined with subsequent collapse of the cover onto the four internal vaults. Material released from the vaults would then be transported by flood waters to the surrounding area and released to the environment as dust once the flood recedes. Early predictions of the frequency of such a flood were

1.0×10^{-4} per year at a maximum elevation of 4,916.6-feet mean sea level well above the 4,912 feet needed to wet the bottom of the bin set #1 berm. The site design accounts for this restriction and new facilities are (or would be designed to be) located above this elevation. Additionally, since floodwaters in relatively flat terrain such as the INEEL rise slowly, adequate time should be available to take protective measures to prevent water from entering the facility (DOE orders require re-evaluation if there has been a significant change in understanding that results in an increase in the site natural phenomena hazard). Given that flood induced failure of bin set #1 was estimated at a frequency of 1.0×10^{-4} per year and failure of one of the remaining bin sets is an order of magnitude less likely, the total probability (P) of a flood-induced release would be:

$$P = A \times B + C \times D \times E$$

where:

A = 4.0 = time (years bin set #1 remains operational) of exposure to flood damage for bin set #1

B = 1.0×10^{-4} per year = Frequency of flood for bin set #1

C = 6.0 = number of other bin sets

D = 1.0×10^{2} = time (years bin sets #2-#7 remain operational) of exposure for bin sets #2-#7

E = 1.0×10^{-5} per year = frequency of flood for bin sets #2-#7

thus:

$$P = 4.0\times10^{-4} + 6.0\times10^{-3} = 6.4\times10^{-3} \text{ per year}$$

More recent flood data indicate that a flood threatening bin set #1 may be much less likely than the 10,000-year flood assumed above and that flood-induced failure of bin sets #2 to #7 are not a credible events. If the present frequency of bin set #1 failure (1.0×10^{-4}) is assumed to be a 95 percent (upper) confidence bound on frequency and a 5 percent (lower) confidence bound of 1.0×10^{-7} is used, then a geometric mean of 3.2×10^{-6} per year for flood failure of bin set #1 is estimated. Therefore, $P = 4.0\times3.2\times10^{-6} + 6.0\times10^{-6} = 2.0\times10^{-5}$, again a design basis event. From this data, it is concluded that the frequency of a flood at the INTEC makes this scenario a design basis event.

No arguments have been made that preclude 1.0×10^{-4} from being an upper bound. In addition, even if a lower bound probability of a flood 3 to 4 orders of magnitude lower were used, the geometric mean of two referenceable sources would be $P = 4 \times$ Geometric Mean of $(1.0\times10^{-4} + 1.0\times10^{-8}) = 4.0\times10^{-4}$. Unless specific design features of the process element warrant a lower frequency, flood-induced failure of bin set #1 is placed in the design basis event frequency bin.

Aircraft Crash

NRC's *Standard Review Plan* [Section 3.5.1.6 in NRC (1997)] assesses the risk of commercial aircraft crashes into nuclear facilities to be on a sliding scale ranging from 1.67×10^{-7} (crashes per square mile – aircraft movement) within a mile of an active runway to 1.2×10^{-9} (crashes per square mile – aircraft movement) at 10 miles. As the distance from the runway increases, the drop in frequency becomes noticeably less, such that it can be assumed conservatively that anywhere beyond 10 miles the frequency of aircraft crashes is 1.0×10^{-9} (crashes per square mile – aircraft movement). Evaluations performed under DOE-STD-3014, for a reactor located near a runway used by military aircraft (McClellan AFB), tend to validate these frequencies for military aircraft (DOE 1996d). There are currently no scheduled flights in or out of Idaho Falls by aircraft heavy enough to penetrate facilities at INTEC; however, it is reasonable to assume that at sometime in the future there may again be flights in and out of the Idaho Falls Airport by aircraft heavy enough to penetrate facilities at INTEC. By this measure, there are at least 2,190 aircraft movements per year that could be a hazard to INTEC facilities, producing a frequency of crashes at INEEL of 2.2×10^{-6} (crashes per square mile – year). INTEC facilities occupy nearly a square mile of area at the INEEL. However, critical facilities such as the bin sets, Tank Farm tanks, and future waste processing facilities associated with various waste processing alternatives do not occupy nearly as much surface area of land. Additionally, previous evaluations of facility vulnerabilities to aircraft impacts at INTEC indicate that a direct release of radioactive or hazardous materials due to an aircraft crash is feasible only if a direct impact to the facility occurs. As such, the average surface area of a critical facility is estimated to be approximately 6 acres or 9.4×10^{-3} square miles. Therefore,

$$\text{Frequency of Critical Facility Aircraft Crash at INTEC} = 2.2\times10^{-6} \times 9.4\times10^{-3} = 2.1\times10^{-8} \text{ per year.}$$

It is noted that this frequency is outside of the 1.0×10^{-6} per year to 1.0×10^{-7} per year range for beyond design basis events. However, due to the potentially catastrophic effects of aircraft crashes into INTEC facilities and to account for likely future increases in flights out of the Idaho Falls Airport, aircraft crashes will be included as an accident initiator in the beyond design basis frequency category.

Based on data available to the accident analysis team, it was determined that past turbulence studies are no longer a concern and that air traffic near INTEC has greatly reduced since generation of previous reports. Thus, the accident frequencies developed above are considered accurate. Previous evaluations of aircraft impacts into bin sets tend to agree on several points: (a) the large, heavy engine assemblies of commercial passenger jets (i.e., 737 and larger) could penetrate the top of bin sets and other enclosed facilities, and (b) smaller aircraft probably would not. Currently, there may be small aircraft flying in the vicinity of INTEC facilities but the only large aircraft capable of penetrating INTEC facilities are those serving the Idaho Falls Airport 50 miles away. The frequency of such an impact (2.1×10^{-8} per year) is estimated based on present aircraft crash data and large aircraft usage at the Idaho Falls Airport. Unless other site activities are proposed that would require use of large aircraft near INTEC, these estimates would not be revised upward. Thus, aircraft crash will remain a beyond design basis event for this EIS.

Extreme-Lightning Damage

Lightning strikes can cause damage to the facility structures, loss of electric power, and damage to operating and safety equipment. The result would be a release of material and a direct pathway to the environment. Three or four lightning strikes have occurred at the INTEC in the last 20 years. These lightning strikes resulted in minor damage but did not lead to releases of radiological and/or chemical inventories. The facility structures are or will be equipped with lightning protection systems designed in accordance with the requirements of NFPA (1997); thus, failures as a result of lightning strikes would be extremely unlikely. In addition to defeating the lightning protection system, a lightning strike would have to be powerful enough to damage facility structures and create a direct leak path to the environment. The frequency of such a strike is deemed to be in the beyond design basis bin, although a fire could be self-sustaining in many locations and raise the likelihood of a material release.

High Wind-Induced Failure

High winds, in the form of tornadoes or straight-line winds, can cause failure of facility structures, operating equipment, safety equipment, or electric power and may result in releases of material and create pathways to the environment. The design basis wind for PC-3 facilities is 95 miles per hour with an annual probability of 1.0×10^{-4} per year. The INEEL Wind Hazard Curve indicates that a straight-line wind with this return frequency would be approximately 90 miles per hour. The wind design criteria for the newly constructed buildings would exceed this threshold. Stronger winds would have an annual probability of less than 1.0×10^{-4} per year and would have to be strong enough to breach the facility structure and internal process systems in order to create a leakage pathway to the environment. Little if any material is at risk. Although the high wind initiator itself would be placed in the design basis frequency bin, the high wind-induced failure scenarios are placed in the beyond design basis frequency bin. Unlike seismic events, which impact the facility structure and internal equipment concurrently, high winds primarily impact the external facility structure. An additional sequence of events would have to occur before contained material inventories are impacted.

Beyond Design Basis Seismic Event

The beyond design basis event earthquake would have a peak ground acceleration that exceeds the design capacity of the facilities and would have a return period greater than 1,000,000 years (1.0×10^{-6} to 1.0×10^{-7} per year). The event would be powerful enough to breach internal process systems (high-efficiency particulate air filters, doors, airlocks, etc.) in order to create a leakage pathway(s) to the environment. This event could be as severe as an airplane crash in the bounding accident determination. The frequency of such an event is deemed to be in the beyond design basis event bin.

Volcanism

Volcanic activity (volcanism) occurring at near field and distant volcanic sources represents a potential external event that could lead to releases of radiological or chemical inventories associated with the waste processing alternatives.

The information in the INEEL Three Mile Island-2 Safety Analysis Report (DOE 1998b) and EDF-TRA-ATR-804 (Hackett and Khericha 1993) indicate that the bounding volcanism-related hazard is due to basaltic volcanism (Hackett and Khericha 1993). Impact to the INTEC due to the other volcanism initiators is considered very unlikely due to geologic changes in the region over millions of years, limited impact areas, and the physical distance to the potential sources. When considering volcanism, mitigation measures to either divert the lava flow or cool the lava are likely to be effective, due mainly to the relatively long period of time (up to a month) between the time of an eruption and the time at which the flow reaches INTEC facilities, the frequency of a basaltic eruption that impacts facilities at INTEC is on the order of 7.0×10^{-7} per year, which places it in the beyond design basis frequency range. This would place basaltic eruptions in the same frequency bin with initiators such as aircraft crashes. As a beyond design basis event, basaltic eruptions are considered bounded from a consequence standpoint by other initiators such as aircraft crashes that involve impact and explosions as well as exposure to high temperatures. This is because the lava flow from the eruption would likely cover the affected structures and limit the release from process vessels and piping.

C.4.1.2.5 Methodology for Integrated Analysis of Risk to Involved Workers

Health and safety risk to involved workers (workers associated with the construction, operation, or decontamination/decommissioning of facilities that implement a waste processing alternative) constitutes a potentially significant "cost" of implementing waste processing alternatives, a source that is being systematically characterized and reported in the HLW EIS. Together with health and safety risk to the public, evaluation of involved worker risk provides a comprehensive basis for comparing waste processing alternatives on the basis of contribution to the implementation risk due to accidents. Unlike health and safety risk to collocated workers and the public that results mainly from facility accidents and accidents occurring during transportation, health and safety risk to involved workers can result from three sources, industrial accidents, exposure to radioactive materials during normal operations, and facility accidents.

- Industrial accident risk to involved workers is the result of accidents that may occur during industrial activities to complete major projects associated with each treatment alternative. Industrial accidents may occur during any of the three major phases of a project, construction, operation, or decontamination/decommissioning. An example of a project, as defined here, would be the Borosilicate Vitrification of calcine waste. Borosilicate Vitrification includes the construction, operation, and decontamination/decommissioning of a vitrification facility plus tasks associated with movement of waste into and out of the facility itself.

- Occupational risk to involved workers results from routine exposure to radioactive materials during the portion of implementation activities that involve exposure to radiation. Occupational risk is not the result of accidents, but is considered along with accident risks as part of the integrated risk to involved workers during implementation of alternatives. Occupational exposures occur mainly during the operation and decontamination/decommissioning phases of a project.

- Facility accident risk to involved workers results from accidents that release radioactive or chemically hazardous materials, accidents (e.g., criticality) that could result in direct exposure to radiation, or energetic accidents (e.g., explosions) that can directly harm workers. Facility accidents pose risk to involved workers in a manner analogous to noninvolved workers and the public, that is, health consequences are the result of workers being receptors for radioactive or chemically hazardous materials that might be released during an accident. For purposes of the EIS, facility accidents are assumed to occur mainly during the operational phase of a project. Facility accidents could occur during the decontamination/decommissioning phase of project activity. However, an accident analysis of facility disposition alternatives, performed for this EIS, evaluated the potential for accidents during the decontamination/decommissioning of existing facilities to be several orders of magnitude smaller than for the same facilities during operation. The assumption is made here that new facilities needed to implement waste processing alternatives would be no worse than existing facilities. Given this assumption, facility accident risk is confined to the operational phase of a project.

Risk to involved workers from occupational exposures and industrial accidents is appraised as part of the health and safety evaluation in the EIS (Appendix C.3). The accident analysis evaluations, include consequences to facility workers. In the integrated involved worker risk evaluation, information used to assess worker risk from industrial accidents and occupational exposures is integrated with results of the facility accidents evaluation to produce a comprehensive perspective on involved worker risk.

The methodology used to evaluate integrated involved worker risk over the life cycle of an waste processing alternative is shown in Figure C.4-6. The total commitment of time, budget, or risk required for implementing a waste processing alternative can be referred to as a life cycle cost. Thus, the life cycle integrated involved worker risk is the sum of worker risk associated with implementation all major projects associated with an alternative. Figure C.4-6 describes how the three types of risk to involved workers are evaluated based on information from the EIS, its supporting documents, and its references.

- Industrial accident risk is the product of total exposure to industrial accidents (number of 100 worker year increments) over the life cycle of an alternative and the rate of fatalities due to industrial accidents (fatalities per 100 worker years).

- Occupational risk is the product of total life cycle exposure to performance of work in a radiation environment (worker years), the average annual dose to workers (rem/worker year), and the rate of latent cancer fatalities to workers (0.0004 fatalities per mrem of exposure).

- Facility accident risk to involved workers is evaluated as the sum of contributions of bounding accidents identified for that alternative. Over the life cycle of an alternative, each contribution is the product of the total probability of accident occurrence (anticipated events during the life cycle), the dose to a population of workers as a result of the accident (mrem), and the rate of latent cancer fatalities. Consequences for involved workers are estimated for bounding accidents with the highest potential consequences to noninvolved workers and the public in the three frequency categories (ABN, DBE, and BDB). Doses to involved workers from an accidental release (of radioactivity) are assumed to be equivalent to doses to persons at 100 meters from the release [for consistency with the definition of facility worker utilized in the SNF & INEL EIS (DOE 1995)] and proportional to doses to noninvolved workers at 640 meters. An evaluation of nuclide contributors to dose at 100 meters was performed for bounding accident scenarios in the EIS. This evaluation identified five nuclides as

Figure C.4-6. Methodology for integrated worker risk evaluation responsible for nearly all the dose to workers at 100 meters. The evaluation also indicated that on average, the dose at 100 meters was a factor of approximately 9 greater than that at 640 meters. Due to limitations on the accuracy of the consequence code at locations near the origin of a release, the factor of 9 was applied to noninvolved worker doses identified for the bounding accidents.

Two types of evaluations integrated involved worker risk evaluations were performed.

- Point estimates were developed by incorporating data from the EIS, its supporting documents, and references into the equations described in Figure C.4-6. These point estimates provide a baseline for comparing waste processing alternatives using integrated involved worker risk, a baseline that is consistent with other alternative comparisons made in the EIS.

- Due to the relatively large uncertainties involved in estimating involved worker risk, the accident analysis methodology for involved worker risk includes the use of Monte Carlo simulation as means of gaining perspective on the importance of sensitivities and uncertainties in the information base. Probabilistic estimates of involved worker risk were developed using the relationships given in Figure C.4-6, information from the EIS, supporting documents, references, and additional information sources to establish bounds on distributed parameters.

Table C.4-8 describes examples of distributions used to perform a probabilistic simulation of integrated involved worker risk over the life cycle of each waste processing alternative.

- Distributions for total exposure were assumed to be triangular, with the point estimate considered the likeliest value. A factor of 2, applied to project a maximum distribution values for life cycle exposure, was determined using published evaluations of cost and schedule overruns for DOE and other Federally funded projects. As one example, a report on the causes of cost growth for DOE and other Federally funded projects suggest that a factor of 50 percent to 300 percent could be used to predict the life cycle cost of a new project (Merrow et al. 1981).

- A distribution for industrial accident fatality rate was assumed to be lognormal, with the point estimate as the geometric mean of the distribution. Although the true shape of the fatality rate distribution is unknown, use of a lognormal is consistent with probabilistic risk assessment treatment of mechanical and electrical system failures that are infrequent but catastrophic in nature. A 95 percent bound was projected using a Bayesian update in an analysis of industrial accident fatality data for the INEEL for the years 1992 through 1998 (Fong 1999).

Table C.4-8. Example parameters for probabilistic simulation of integrated involved worker risk.

Contributor	Distribution type	Distribution parameters	References
Life cycle exposure to industrial accidents	Triangular	Minimum = 2223 wk-yr Likeliest = 5267 wk-yr Maximum = 5336 wk-yr	Appendix C.3 (Merrow et al. 1981)
Rate of fatal industrial accidents	Lognormal	Geo mean = 0.011 fatalities/ 100 wk-yr 95% bound = 0.0141 fatalities/ 100 wk-yr	Millet (1998); Fong (1999)
Life cycle occupational exposure to radiation	Triangular	Minimum = 2223 wk-yr Likeliest = 5267 wk-yr Maximum = 5336 wk-yr	Appendix C.3 (Merrow et al. 1981)
Occupational dose rate to workers	Lognormal	10% bound = 0.18 rem/wk-yr 90% bound = 0.24 rem/wk-yr	Appendix C.3
Risk to workers from facility accidents	Lognormal	Geo mean = 1.94 fatalities 95% bound = 19.4 fatalities	TRD Appendices C & 1

- A distribution for facility accident risk was assumed to also be lognormal, with the point estimate as the geometric mean of the distribution. A 95 percent bound was projected using experience from probabilistic risk assessments of commercial nuclear power facilities.

C.4.1.3 Accidents with Potential Release of Radioactive Materials

C.4.1.3.1 Screening for Radioactive Material Accidents

This section discusses the results of the first level of screening evaluations used to select process elements for analysis in the TRD. Results of the preliminary prioritization of process elements based on potential hazards and safety vulnerabilities is summarized in Table C.4-9 with supporting information given in Table C.4-10. In Table C.4-9, process elements are ranked as:

I. Inventory at risk and frequency of accidental release are likely to produce bounding accident for treatment alternative.

II. Inventory at risk and frequency of accidental release could credibly produce a bounding accident scenario.

III. Process element does not contain sufficient inventory or driving release energy to result in bounding scenario.

Process elements prioritized as I- or II-level vulnerabilities in the initial screening receive a detailed accident analysis. In Table C.4-9, those process elements that would result in level II vulnerabilities are shaded. Table C.4-10 provides a cross-reference between the screening review and the accident analysis performed in Appendix A of the TRD. In particular, Table C.4-10 identifies the minimum set of accident analysis (22) required to comprehensively evaluate the process elements in Table C.4-9 that would result in level I or II vulnerabilities. Using the screening and cross-referencing process to define accident analyses requirements assures that all major vulnerabilities associated with the waste processing alternatives are considered in the selection process.

Not all process elements require a separate accident analysis. Table C.4-10 identifies a minimum set of accident analyses necessary to fully assess the accident potential for all ranks I and II process elements. There are a total of 22 required accident evaluations that are indicated in Table C.4-10. However, two of these evaluations (13 and 19) were subsequently not used.

C.4.1.3.2 Potentially Bounding Abnormal Event Accidents

Twenty-four potentially bounding events accidents were evaluated and discussed in Section 3.2.1 of the TRD. These 24 abnormal events are summarized in Table C.4-11. Detailed frequency range characterization and source terms for each potentially bounding abnormal event accident can be found in the TRD.

C.4.1.3.3 Potentially Bounding Design Basis Event Accidents

Twenty-four potentially bounding design basis event accidents were evaluated and discussed in Section 3.2.2 of the TRD. These 24 design basis events are summarized in Table C.4-12. Detailed frequency range characterization and source terms for each potentially bounding design basis event accident can be found in the TRD.

C.4.1.3.4 Potentially Bounding Beyond Design Basis Event Accidents

Twenty-four potentially bounding beyond design basis event accidents were evaluated and discussed in Section 3.2.3 of the TRD. These 24 beyond design basis events are summarized in Table C.4-13. Detailed frequency range characterization and source terms for each potentially bounding beyond design basis event accident can be found in the TRD.

C.4.1.4 Accidents with Potential Release of Toxic Chemicals

C.4.1.4.1 Screening for Accidents Involving Hazardous Chemicals

A significant number of chemical compounds are stored at and used at INTEC facilities. Such chemical compounds could be released during accidents that would result in human health risk or environmental consequences. Therefore, a comprehensive evaluation of facility accidents for waste processing alternatives requires identification of potentially bounding accidents involving release of chemical hazardous materials.

Hazardous chemical releases may directly result in offsite injuries, illnesses, or fatalities. Direct impact from a release of a toxic gas such as ammonia in sufficient quantity to form a vapor cloud could endanger involved workers at the facility, noninvolved workers on the site, and members of the general public traveling on or near the site boundaries. Alternatively, such releases may initiate a sequence of indirect events that result in a release of radioactive materials. An indirect impact, such as an undetected release of a toxic chemical such as chlorine, could find its way into a building ventilation system and could incapacitate facility operators in the facility and prevent the shutdown process for equipment containing radioactive materials. Without operator control, the process equipment malfunctions could result in an accidental release of radioactive material. Two potentially bounding accident scenarios from the detailed accident evaluation process produced chemical (kerosene) releases to the groundwater. In theory, groundwater releases of chemicals can be mitigated, with little ultimate impact on the public. However, both of these accident scenarios are described below.

The purpose of the screening evaluation is to identify conditions associated with implementation of the waste processing alternatives, such as the presence of significant hazardous material inventories in or near facilities or use of several incompatible materials in proximity to each other, that could be initiators of accident scenarios.

Systematic review of process elements of Table C.4-9 and accident analysis of Table C.4-10 was performed to identify conditions where hazardous chemical inventories were required, processes could result in the formation of hazardous chemicals, or equipment accidents could result in conditions where hazardous chemicals could be produced and released.

This review of process elements yielded the following observations:

- To meet expected maximum achievable control technology upgrade requirements, the presently designed offgas treatment system utilizes a significant quantity of kerosene to achieve elevated temperatures and more complete combustion of offgas constituents.

- Several HLW treatment processes such as separations require additional offgas treatment capabilities not currently performed at INEEL. Current feasibility studies for several waste processing alternatives identify a need for additional offgas treatment to meet EPA environmental requirements during separation, vitrification and other functions associated with alternative implementation. These same feasibility studies have identified an ammonia-based treatment process as being most likely to meet the technical requirements of the HLW alternatives. Thus ammonia has been identified as a chemical substance posing a potentially significant hazard to workers and the public during HLW alternative implementation. Recent design studies have identified alternative processes for meeting environmental compliance requirements. However, at this time the ammonia-based process is still considered a potential source of bounding accidents.

- Some batch processes, such as cesium separation, require the use of potentially incompatible chemicals to clean and revitalize equipment.

- Fires in some process equipment could result in the evolution and release of hazardous materials.

Using this screening approach, accident evaluations 2, 4, 6, and 15 for "abnormal events" were identified as having potential hazardous chemical release scenarios. Accident evaluations 2 and 15 for "design basis events" were identified for potential hazardous chemical release, and accident evaluations 2 and 15 for "beyond design basis" were also identified for potential hazardous chemical release. The screening approach employed here is considered sufficient to identify accidents resulting from chemical releases in the process. The following Sections C.4.1.4.2 to C.4.1.4.4 describe these accident evaluations that have potential for hazardous chemical release.

C.4.1.4.2 Potentially Bounding Abnormal Events Accidents Involving Release of Toxic Chemical

Four potentially bounding abnormal event accidents involving release of toxic chemical were evaluated and discussed in Section 4.2.1 of the TRD. These four abnormal events are summarized in Table C.4-14.

C.4.1.4.3 Potentially Bounding Design Basis Accidents Involving Release of Toxic Chemicals

Two potentially bounding design basis event accidents involving release of toxic chemical were evaluated and discussed in Section 4.2.2 of the TRD. These two design basis events are summarized in Table C.4-15.

C.4.1.4.4 Potentially Bounding Beyond Design Basis Accidents Involving Release of Toxic Chemicals

Two potentially bounding beyond design basis event accidents involving release of toxic chemical were evaluated and discussed in Section 4.2.3 of the TRD. These two beyond design basis events are summarized in Table C.4-16.

C.4.1.5 Facility Accident Consequences Assessment

Consequences Assessment

Radiological source terms were used as input into the computer program Radiological Safety Analysis Computer Program (RSAC-5) to estimate human health consequences for radioactive releases (King 1999a). DOE used this program to determine the radiation doses at receptor locations from the airborne release and transport of radionuclides from each accident sequence. Meteorological data used in the program was selected to be consistent with previous INEEL EIS analyses (i.e., SNF and INEL EIS) and are for 95 percent meteorological conditions. The 95 percent meteorological condition represents the meteorological conditions that could produce the highest calculated exposures. This is defined as that condition which is not exceeded more than 5 percent of the time or is the worst combination of weather stability class and wind speed.

The population radiation doses from the computer output were then converted into expected latent cancer fatalities using dose-to-risk conversion factors recommended by the National Council on Radiation Protection and Measurements. No data indicate that small radiation doses cause cancer; to be conservative, however, the National Council on Radiation Protection and Measurements assumes that any amount of radiation carries some risk of inducing cancer. DOE has adopted the National Council on Radiation Protection and Measurements factor of 5×10^{-4} latent cancer fatalities for each person-rem of radiation dose to the general public for doses less than 20 rem. For larger doses, when the rate of exposure would be greater than 10 rads (radiation absorbed dose) per hour, the increased likelihood of

latent cancer fatality is doubled, assuming the body's diminished capability to repair radiation damage. DOE calculated the expected increase in the number of latent cancer fatalities above those expected for the population.

The consequences from accidental chemical releases were calculated using the computer program Areal Locations of Hazardous Atmospheres (ALOHA). Because chemical consequences are based on concentration rather than dose, the computer program calculated air concentrations at a selected receptor location. Meteorological assumptions used for chemical releases were the same as used for radiological releases.

The HLW & FD EIS accident analysis consequence modeling was performed for three receptors:

- Maximally-exposed individual
- Noninvolved worker
- Offsite population (population dose)

For each of these evaluations, conservative assumptions were applied to obtain bounding results. For the most part, the assumptions in the HLW & FD EIS were consistent with those applied in other EIS documents prepared at the INEEL, such as the SNF & INEL EIS (DOE 1995). However, there were some assumptions that differed.

The approach that was taken in the HLW & FD EIS consequence modeling was to ensure that a "safety envelope" was provided. This approach differs from the approach taken in other EISs, such as the SNF & INEL EIS where certain mitigation actions were credited up front and other probabilistic arguments were applied to reduce the predicted consequences. Due to this, the results presented in the HLW & FD EIS are larger than the results that would have been obtained by applying the SNF & INEL EIS assumptions (DOE 1995). However, the key issue at hand is that the Idaho HLW & FD EIS is providing a likely upper bound to the potential consequences for the accidents associated with the candidate alternatives. In addition, these conservative assumptions were incorporated in a consistent manner. Although adjustments to these assumptions will modify the absolute magnitudes of the predicted consequences, they will not modify the relative ranking. So the set of bounding scenarios are anticipated to remain the same.

DOE decided not to evaluate impacts from some initiators (i.e., volcanoes) because they determined that these initiators would not provide new opportunities to identify bounding accidents. Based on evaluations in the TRD, volcanic activity impacting the INTEC was considered a beyond design basis event. This would place the event with initiators such as aircraft crashes and beyond design basis earthquakes. However, based on the phenomena associated with these initiators, volcanic activity-initiated events are considered bounded by other initiators. This is because the lava flow from the eruption (basaltic volcanism) would likely cover the affected structures. Therefore, the amount that is released from process vessels and piping due to lava flow would be limited and would be bounded by events such as aircraft crashes, where the entire inventory would be impacted and available for release. See Section C.4.1.2.4 of this Appendix for more detail on volcanism.

Accidents that resulted in a release only to groundwater were not generally evaluated since the time between their occurrence and their impact on the public was assumed to be long enough to take comprehensive mitigation measures. The one exception, DOE did identify bounding groundwater release accidents for which effective mitigation might not be feasible.

C.4.1.5.1 Radiological Impacts of Implementing the Alternatives

This section analyzes the impacts or consequences of implementing the HLW processing alternatives and their options. It describes (1) the major processes of each alternative, (2) the bounding accident scenarios applicable to the major processes, and (3) the resulting impact to INEEL workers and the general public. The systematic accident analysis process employed by DOE identified potentially bounding accidents for each alternative/option. The results for radiological releases are expressed in terms of the estimated impacts for the maximally-exposed individual, noninvolved worker, offsite population, and the latent cancer fatalities for the offsite population. After evaluating the human health consequences associated with these potentially bounding accidents, DOE selected three bounding accidents (one abnormal, one design basis, and one beyond design basis) for each of the processes with the particular alternative/option. Consequences for each of the potentially bounding accident scenarios are given in the tabular summaries associated with each alternative and each frequency category in the TRD.

In general, the process used in selecting the bounding accident scenario was to select the scenario with the highest consequence within each frequency bin. In some cases, one scenario had the highest consequence for the maximally-exposed individual and noninvolved worker but another scenario had higher consequences for the offsite population and latent cancer fatalities. In these cases, the scenario with the higher consequences for the offsite population/latent cancer fatalities was selected. Although this is the rule of thumb, there were several exceptions to this.

1. Abnormal and Design Basis Events for the "Active" Alternatives – Operational failures associated with the removal of calcine from bin set 1 and flood-induced failure of bin set #1 are bounding abnormal and design basis events respectively that affect all waste processing alternatives/options. In order to compare waste processing alternatives, these two accidents have been shown separately in Table C.4-17 as accidents that cross cut treatment alternatives. In order to provide additional resolution in determining the highest risk alternatives, the scenario with the second highest consequence is also highlighted as a "bounding" scenario.

2. Highest Risk vs. Highest Consequence Scenario – Risk is defined as the product of frequency and consequence. In some cases, the scenario with the perceived higher risk was selected even though another scenario had higher consequences. The frequency bands considered in the analysis were fairly wide. For instance, the design basis frequency band is from 1.0×10^{-3} per year to 1.0×10^{-6} per year. From a risk standpoint, a scenario that is a 1,000 times more likely (e.g., 1.0×10^{-3} per year vs. 1.0×10^{-6}, per year), has a higher risk than another scenario that has a consequence that is 100 times greater. Therefore, the approach taken was to select the higher frequency/lower consequence scenario as the bounding scenario. These are identified on a case by case basis and identified in the relevant sections following.

3. Reconsideration of Conservatism in Model – In some scenarios, assumptions used in the development of source terms for the accident scenarios were determined to be highly conservative under different operating conditions. For instance, the beyond design basis accident for AA14 was assumed to be the same as for AA4. This is true for most alternatives except for the Continued Current Operations Alternative due to the differences in process requirements. These are noted on a case-by-case basis and identified in the relevant sections following.

Summary tables in the TRD describe potentially bounding accidents and their forecasted consequences. The TRD also provides additional information with respect to the process used to identify potentially bounding accidents, their source terms, and consequences. Table C.4-17 provides a summary of bounding radiological events for the various waste processing alternatives. It should be noted that it is a misconception that a DBE should have a smaller consequence than a BDB event. Table C.4-17 shows

that the No Action Option, Continued Current Operations Option, and the Hot Isostatic Pressed Waste Option all have higher DBE consequences than their DBD consequences. This phenomena is not common but it is not wrong.

The following paragraphs describe the accident consequences associated with each of the waste processing alternatives.

No Action Alternative

Alternative/Process Data – Three major processes or functions apply to and form the basis of this accident analysis for the No Action Alternative. These three processes are listed below and described in more detail in the TRD.

1. Calcine Retrieval and Onsite Transport (bin set 1 only) (AA03).
2. Long-Term Onsite Storage of Calcine in Bin Sets (AA20).
3. Long-Term Onsite Storage of SBW (AA22).

Accident Consequence – The systematic accident analysis process employed by DOE identified potentially bounding accidents for the No Action Alternative associated with the three functional activities described above. After evaluating the human health consequences associated with these potentially bounding accidents, DOE selected three bounding accidents (one abnormal, one design basis, and one beyond design basis) for each of the three processes. Summary tables in the TRD describe potentially bounding accidents and their forecasted consequences. The TRD also provides additional information with respect to the process used to identify potentially bounding accidents, their source terms, and consequences. Table C.4-17 provides a summary of the bounding radiological events for the No Action Alternative. This summary table (C.4-17) shows that degradation of the bin sets over time (after 2095, ABN20), seismic failure of a bin set (after 2095, DBE20), and an aircraft crash into a bin set (BDB20) result in the bounding abnormal, design basis, and beyond design basis accidents, respectively, for this alternative.

Continued Current Operations Alternative

Alternative/Process Data – Eight major processes or functions apply to and form the basis of this accident analysis for the Continued Current Operations Alternative. These eight processes are listed below and described in more detail in the TRD.

1. New Waste Calcining Facility Continued Operation (AA01).

2. New Waste Calcining Facility High Temperature and Maximum Achievable Control Technology Modifications (Off-Gas Treatment Facility Only)(AA02).
3. Calcine Retrieval and On-Site Transport (Bin Set 1 Only) (AA03).
4. Cesium Separation (Cesium Ion Exchange Only) (AA06).
5. Liquid Waste Stream Evaporation (AA14).
6. Long Term Onsite Storage of Calcine in Bin Sets (AA20).
7. Transuranic Stabilization and Preparation for Transport to Waste Isolation Pilot Plant (Transuranic or Transuranic and Strontium Feedstocks) (AA21).
8. SBW Retrieval and Onsite Transport (AA24).

Accident Consequence – The systematic accident analysis process employed by DOE identified potentially bounding accidents for the Continued Current Operations Alternative associated with the eight functional activities described above. After evaluating the human health consequences associated with these potentially bounding accidents, DOE selected three bounding accidents (one abnormal, one design basis, and one beyond design basis) for each of the eight processes. Summary tables in the TRD describe potentially bounding accidents and their forecasted consequences. The TRD also provides additional information with respect to the process used to identify potentially bounding accidents, their source terms, and consequences. Table C.4-17 provides a summary of the bounding radiological events for the Continued Current Operations Alternative. This summary table (C.4-17) shows that degradation of the bin sets over time (after 2095, ABN20), seismic failure of a bin set (after 2095, DBE20), and an aircraft crash into a bin set (BDB20) result in the bounding abnormal, design basis, and beyond design basis accidents, respectively, for this alternative.

Separations Alternative – Full Separations Option

Alternative/Process Data – Six major processes or functions apply to and form the basis of the accident analysis for the Full Separations Option. These six processes are listed below and described in more detail in the TRD.

1. Calcine Retrieval and Onsite Transport (AA03).
2. Full Separation (Cesium Ion Exchange, Transuranic Extraction, and Strontium Extraction (AA04).
3. Borosilicate Vitrification (Cesium, Transuranic, and Strontium Feedstocks) (AA08).
4. Liquid Waste Stream Evaporation (AA14).

5. Additional Off-Gas Treatment (AA15).

6. SBW Retrieval and Onsite Transport (AA24).

Accident Consequence – The systematic accident analysis process employed by DOE identified potentially bounding accidents for the Full Separations Option associated with the six functional activities described above. After evaluating the human health consequences associated with these potentially bounding accidents, DOE selected three bounding accidents (one abnormal, one design basis, and one beyond design basis) for each of the six processes. Summary tables in the TRD describe potentially bounding accidents and their forecasted consequences. The TRD also provides additional information with respect to the process used to identify potentially bounding accidents, their source terms, and consequences. Table C.4-17 provides a summary of the bounding radiological events for the Full Separations HLW Treatment Option. This summary table (C.4-17) shows that a failure during SBW retrieval (ABN24), an operational failure during the full separations processes (DBE04), and an aircraft crash into the Borosilicate Vitrification Facility (BDB08) result in the bounding abnormal, design basis, and beyond design basis events, respectively, for this alternative.

Separations Alternative – Planning Basis Option

Alternative/Process Data – Nine major processes or functions apply to and form the basis of the accident analysis for the Planning Basis Option. These nine processes are listed below and described in more detail in the TRD.

1. New Waste Calcining Facility Continued Operation (AA01).

2. New Waste Calcining Facility High Temperature and Maximum Achievable Control Technology Modifications (AA02).

3. Calcine Retrieval and Onsite Transport (AA03).

4. Full Separation (Cesium Ion Exchange, Transuranic Extraction, and Strontium Extraction) (AA04).

5. Borosilicate Vitrification (Cesium, Transuranic, and Strontium Feedstocks) (AA08).

6. Liquid Waste Stream Evaporation (AA14).

7. Additional Off-Gas Treatment (AA15).

8. Transuranic Stabilization and Preparation for Transport to the Waste Isolation Pilot Plant (Transuranic or Transuranic and Strontium Feedstocks) (AA21).

9. SBW Retrieval and Onsite Transport (AA24).

Accident Consequence – The systematic accident analysis process employed by DOE identified potentially bounding accidents for the Planning Basis Option associated with the nine functional activities described above. After evaluating the human health consequences associated with these potentially bounding accidents, DOE selected three bounding accidents (one abnormal, one design basis, and one beyond design basis) for each of the six processes. Summary tables in the TRD describe potentially bounding accidents and their forecasted consequences. The TRD also provides additional information with respect to the process used to identify potentially bounding accidents, their source terms, and consequences. Table C.4-17 provides a summary of the bounding radiological events for the Planning Basis Option. This summary table (C.4-17) shows that an operational failure during SBW retrieval (ABN24), a failure during continued operation of the calcining facility (DBE01), and an aircraft crash into the Borosilicate Vitrification Facility (BDB08) result in the bounding abnormal, design basis, and beyond design basis accidents respectively, for this alternative.

Separations Alternative – Transuranic Separations Option

Alternative/Process Data – Eight major processes or functions apply to and form the basis of this accident analysis for the Transuranic Separations Option. These eight processes are listed below and described in more detail in the TRD.

1. Calcine Retrieval and Onsite Transport (AA03).
2. Transuranic Separation (Transuranic Extraction Only) (AA05).
3. Class C Grout (AA07).
4. Liquid Waste Stream Evaporation (AA14).
5. Additional Off-Gas Treatment (AA15).
6. Class C Grout Disposal (AA16).
7. Transuranic Stabilization and Preparation for Transport to the Waste Isolation Pilot Plant (Transuranic or Transuranic and Strontium Feedstocks) (AA21).
8. SBW Retrieval and Onsite Transport (AA24).

Accident Consequence – The systematic accident analysis process employed by DOE identified potentially bounding accidents for the Transuranic Separations Option associated with the eight functional activities described above. After evaluating the human health consequences associated with these potentially bounding accidents, DOE selected three bounding accidents (one abnormal, one design basis, and one beyond design basis) for each of the eight processes. Summary tables in the TRD describe potentially bounding accidents and their forecasted consequences. The TRD also provides additional information with respect to the process used to identify potentially bounding accidents, their source terms, and consequences. Table C.4-17 provides a summary of the bounding radiological events for the Transuranic Separations Option. This summary table (C.4-17) shows that an operational failure during Class C Grout Disposal (ABN11), an operational failure during the transuranic separations process (DBE05), and an aircraft crash into the transuranic separations facility (BDB05) result in the bounding abnormal, design basis, and beyond design basis accidents, respectively, for this alternative.

Non-Separations Alternative – Hot Isostatic Pressed Waste Option

Alternative/Process Data – Eight major processes or functions apply to and form the basis of this accident analysis for the Hot Isostatic Pressed Waste Option. These eight processes are listed below and described in more detail in the TRD.

1. New Waste Calcining Facility Continued Operations (AA01).
2. New Waste Calcining Facility High-Temperature and Maximum Achievable Control Technology Modifications (Off-Gas Treatment Facility Only) (AA02).
3. Calcine Retrieval and Onsite Transport (AA03).
4. High-Level Waste/SBW Immobilization for Transport (Hot Isostatic Press) (AA11).
5. Liquid Waste Stream Evaporation (AA14).
6. Additional Off-Gas Treatment (AA15).
7. Transuranic Stabilization and Preparation for Transport to the Waste Isolation Pilot Plant (Transuranic or Transuranic and Strontium Feed stocks) (AA21).
8. SBW Retrieval and Onsite Transport (AA24).

Accident Consequence – The systematic accident analysis process employed by DOE identified potentially bounding accidents for the Hot Isostatic Pressed Waste Option associated with the eight functional activities described above. After evaluating the human health consequences associated with these potentially bounding accidents, DOE selected three bounding accidents (one-abnormal, one-design basis, and one-beyond design basis) for each of the eight processes. Summary tables in the TRD describe potentially bounding accidents and their forecasted consequences. The TRD also provides for additional information with respect to the process used to identify potentially bounding accidents, their source terms, and consequences. Table C.4-17 provides a summary of the bounding radiological events for the Hot Isostatic Pressed Waste Option. This summary table (C.4-17) shows that an operational failure during SBW retrieval (ABN24), a failure during continued operation of the calcining facility (DBE01), and an aircraft crash into the liquid waste evaporation process (BDB14) result in the bounding abnormal, design basis, and beyond design basis accidents, respectively, for this alternative.

Non-Separations Alternative – Direct Cement Waste Option

Alternative/Process Data – The Direct Cement Waste Option has eight major processes or functions that have applicability to this accident analysis. These eight processes are listed below and described in more detail in the TRD.

1. New Waste Calcining Facility Continued Operation (AA01).
2. New Waste Calcining Facility with High-Temperature and Maximum Achievable Control Technology Modifications (Off-Gas Treatment Facility Only) (AA02).
3. Calcine Retrieval and Onsite Transport (AA03).
4. Direct Cement Waste Immobilization for Transport (AA12).
5. Liquid Waste Stream Evaporation (AA14).
6. Additional Off-Gas Treatment (AA15).
7. Transuranic Stabilization and Preparation for Transport to the Waste Isolation Pilot Plant (Transuranic or Transuranic and Strontium Feedstocks) (AA21).
8. SBW Retrieval and Onsite Transport (AA24).

Accident Consequence – The systematic accident analysis process employed by DOE identified potentially bounding accidents for the Direct Cement Waste Option associated with the eight functional activities described above. After evaluating the human health consequences associated with these potentially bounding accidents, DOE selected three bounding accidents (one abnormal, one design basis, and one beyond design basis) for each of the eight processes. Summary tables in the TRD describe potentially bounding accidents and their forecasted consequences. The TRD also provides additional information with respect to the process used to identify potentially bounding accidents, their source terms, and consequences. Table C.4-17 provides a summary of the bounding radiological events for the Direct Cement Waste Option. This summary table (C.4-17) shows that an operational failure during SBW retrieval (ABN24), a failure during continued operation of the calcining facility (DBE01), and an aircraft crash into the direct cement process facility (BDB12) result in the bounding abnormal, design basis, and beyond design basis accidents, respectively, for this alternative.

Non-Separations Alternative - Early Vitrification Option

Alternative/Process Data - The Early Vitrification Option has five major processes or functions that have applicability to this accident analysis. These five processes are listed below and described in more detail in the TRD.

1. Calcine Retrieval and Onsite Transport (AA03). See the description of this process under the No Action Alternative.
2. Borosilicate Vitrification (Calcine and SBW Feedstocks) (AA09).
3. Additional Off-Gas Treatment (AA15).
4. SBW Stabilization and Preparation for Transport to Waste Isolation Pilot Plant (AA23).
5. SBW Retrieval and Onsite Transport (AA24).

Accident Consequence - The systematic accident analysis process employed by DOE identified potentially bounding accidents for the Early Vitrification Option associated with the five functional activities described above. After evaluating the human health consequences associated with these potentially bounding accidents, DOE selected three bounding accidents (one abnormal, one design basis, and one beyond design basis) for each of the five processes. Summary tables in the TRD describe potentially bounding accidents and their forecasted consequences. The TRD also provides additional information with respect to the process used to identify potentially bounding accidents, and their source terms, and consequences. Table C.4-17 provides a summary of the bounding radiological events for the Early Vitrification Option. This summary table (C.4-17) shows that an operational failure during SBW retrieval (ABN24), an operational failure during operation of the Borosilicate Vitrification Facility (DBE09), and an aircraft crash into the Borosilicate Vitrification Facility (BDB09), result in the bounding abnormal, design basis, and beyond design basis accidents, respectively, for this alternative.

Minimum INEEL Processing Alternative

Alternative/Process Data - The Minimum INEEL Processing Alternative has nine major processes or functions that have applicability to this accident analysis. These nine processes are listed below and described in more detail in the TRD.

1. Calcine Retrieval and On-Site Transport (AA03).
2. Cesium Separation (Cesium Ion Exchange Only) (AA06).
3. Class C Grout Process (AA07).
4. HLW/SBW Immobilization for Transport (Calcine and Cesium Ion Exchange Resin Feedstocks) (AA10).
5. Additional Off-Gas Treatment (AA15).
6. High-Level Waste Interim Storage for Transport (AA17).
7. High-Level Waste/High-Activity Waste Stabilization and Preparation for Transport (Calcine and Cesium Resin Feedstocks) (AA18).
8. Contact-Handled Transuranic Stabilization and Preparation for Transport to Waste Isolation Pilot Plant (Transuranic or Transuranic and Strontium Feedstocks) (AA21).
9. SBW Retrieval and Onsite Transport (AA24).

Accident Consequence - The systematic accident analysis process employed by DOE identified potentially bounding accidents for the Minimum INEEL Processing Alternative associated with the nine functional activities described above. After evaluating the human health consequences associated with these potentially bounding accidents, DOE selected three bounding accidents (one abnormal, one design basis, and one beyond design basis) for each of the nine processes. Summary tables in the TRD describe potentially bounding accidents and their forecasted consequences. The TRD also provides additional information with respect to the process used to identify potentially bounding accidents, their source terms, and consequences. Table C.4-17 provides a summary of the bounding radiological events for the Minimum INEEL Processing Alternative. This summary table (C.4-17) shows that an operational failure during high level waste interim storage (ABN17), an inadvertent criticality during transuranic stabilization and packaging (DBE21), and an aircraft crash into casks awaiting transport to the Hanford Site (BDB17) result in the bounding abnormal, design basis, and beyond design basis accidents, respectively, for this alternative.

C.4.1.5.2 Impacts of Chemical Release Accidents to Implement the Alternatives

This section analyzes the impacts or consequences of chemical releases from accidents that could occur as a result of implementing the HLW processing alternatives and their options. It identifies (1) the major processes that contribute chemicals to the atmosphere during an accident and (2) the impacts to INEEL workers and the general public in terms of Emergency Response Planning Guideline values at 3,600 meters.

Alternative/Process Data – Two major processes or functions can produce chemical releases from accidents resulting during implementation of waste processing alternatives.

1. New Waste Calcining Facility High Temperature and Maximum Achievable Control Technology Modifications (AA02).

2. Additional Off-Gas Treatment (AA15).

Accident Consequence – Summary Tables C.4-18 through C.4-20 present the chemical accidents and the impacts of these accidents.

C.4.1.5.3 Groundwater Impacts of Implementing the Alternatives

The bounding accident scenarios described in the preceding sections produce human health consequences mainly as a result of inhalation of air releases. In the National Environmental Policy Act accident analysis, it is generally assumed that the inhalation pathway is the predominant source of human health consequences since an air release does not provide an opportunity for intervention and mitigation.

Several potentially bounding accident scenarios from the detailed accident evaluation process produced mainly groundwater releases. In theory, all groundwater releases can be mitigated with little ultimate impact on the public. However, since significant groundwater releases would produce a substantive risk to the environment and the opportunity to mitigate may be limited by time and resource constraints, the impact of accident scenarios resulting in groundwater releases is considered in the facility accidents evaluation.

Table C.4-18. Abnormal events that produce chemical impacts.

AA	Process title	Abnormal event	Contaminant	Peak atmospheric concentration (ERPG)
15	**Additional Off-Gas Treatment**	**Failure of ammonia tank connections results in a spill of 150 pounds per minute of liquid ammonia. A fraction of the ammonia would flash to vapor as it escapes the tank. The remainder would settle and form a boiling pool.**	**Ammonia**	**Less than ERPG-2 at 3,600 meters**

ERPG = Emergency Response Planning Guidance.

Table C.4-19. Design basis events that produce chemical impacts.

AA	Process title	Design basis events	Contaminant	Peak atmospheric concentration (ERPG)
02	New Waste Calcining Facility High Temperature & Maximum Achievable Control Technology Modifications	A carbon filter bed fire. Inadequate nitrous oxide destruction in the reduction chamber of the multi-stage combustion system leads to exothermic reactions in the filter bed. The heat buildup could result in a carbon bed fire and a release of radioactive material (iodine-129) and mercury embedded in the filter bed and corresponding HEPA filter fire.[a]	Mercury	Greater than ERGP-2[b] at 3,600 meters.
15	**Additional Off-Gas Treatment**	**Failure of ammonia tank connections results in a spill of 1,500 pounds per minute of liquid ammonia. A fraction of the ammonia would flash to vapor as it escapes the tank. The remainder would settle and form a boiling pool.**	**Ammonia**	**Greater than ERPG-2 at 3600 meters**

ERPG = Emergency Response Planning Guideline.

a. This accident also results in a chemical release to the atmosphere. This accident has been evaluated as a potential atmospheric release in Section C.4.5.2 to assess its potential as an additional source of human health and environmental risk.

b. There is no standard ERPG value for mercury vapor. However, there is a standard method to calculate an ERPG using the Threshold Limit Value – Time Weighted Average (TLV-TWA). In this case the equivalent ERPG-2 value is [(3) (TLV-TWA)] = 0.1 ppm.

Table C.4-20. Beyond design basis events that produce chemical impacts.

AA	Process title	Beyond design basis	Contaminant	Peak atmospheric concentration (ERPG)
15	**Additional Off-Gas Treatment**	**Failure of ammonia tank connections results in a spill of 15,000 pounds per minute of liquid ammonia. A fraction of the ammonia would flash to vapor as it escapes the tank. The remainder would settle and form a boiling pool.**	**Ammonia**	**Greater than ERPG-2 at 3,600 meters**

ERPG = Emergency Response Planning Guideline.

Environmental risk is usually presented in the Remedial Investigation/Feasibility Study process in terms of expected contamination at the site boundary as a function of time. Therefore, the metrics of environmental risk such as Maximum Contaminant Level can be used to estimate the potential for future adverse human health impacts. Specifically, expected contamination due to a postulated release can be compared with Maximum Contaminant Level values to assess the severity of environmental risk associated with a release. In this way, accident scenarios resulting in a release to groundwater can be appraised for their potential contribution to environmental risk and the overall economic impact of the accident.

Alternative/Process Data – Two major processes or functions can produce groundwater releases from accidents resulting during implementation of waste processing alternatives.

1. New Waste Calcining Facility High Temperature and Maximum Achievable Control Technology Modifications (AA02).

2. Long-Term Onsite Storage of SBW (AA22).

Accident Consequence – For the purposes of the Idaho HLW & FD EIS, the complex subsurface transport calculations used to negotiate performance requirements for the INEEL Environmental Management Program are not needed. Potential impacts that could result from previous spills have already been evaluated at the Waste Area Group using subsurface modeling at INTEC as well as a simple screening model approach. The following paragraphs discuss the simplified screening method used to estimate the impacts from major groundwater release accidents identified in this Idaho HLW & FD EIS accident analysis. More detail on the methods used are presented in King (1999b). Abnormal and beyond design basis events for AA02, a leak of kerosene to the environment due to equipment failures, result in the release of 15,000 gallons and 30,000 gallons, respectively, of kerosene to the surface soil and subsequent infiltration through the vadose zone to groundwater, the primary concern is the migration of the toxic constituents of the kerosene. A primary toxic constituent of kerosene is benzene, which has an EPA Maximum Contaminant Level of 5 micrograms/liter. The expected peak groundwater concentration of benzene for the 15,000-gallon spill is approximately 120 micrograms/liter at the edge of the spill when assuming infiltration from normal precipitation. The expected peak groundwater concentration of benzene for the 30,000-gallon spill is approximately 180 micrograms/liter at the edge of the spill when assuming infiltration from normal precipitation. The groundwater impact from such spills is that the Maximum Contaminant Level for benzene would be exceeded by a factor of 24 for the 15,000-gallon spill and a factor of 36 for the 30,000-gallon spill. Both accidents assume that the kerosene would form a pool about 3 inches deep before seeping into the subsurface. The benzene component of the kerosene may require about 200 years to reach the groundwater under normal precipitation conditions.

The simplified modeling approach used to evaluate groundwater impacts from kerosene could not be used to evaluate the results of a major earthquake that ruptures a SBW tank in the design basis event for AA22. Therefore, the migration of the radionuclides present in the SBW located in the tank farm tanks was evaluated using the same numerical modeling approach for assessing the potential risk via groundwater ingestion as outlined in the OU3-13 RI/BRA report (Rodriguez et al. 1997). This approach evaluates risk via ingestion of groundwater based on modeling of geologic and hydrologic conditions, natural and anthropogenic sources of water, contaminant source locations, contaminant masses, activities, as well as release history and geochemical characteristics of existing contaminants. For the SBW tank failure due to a major earthquake, the radionuclide bearing waste was assumed to be released to the subsurface soil, infiltrate and disperse through the vadose zone and migrate in the groundwater. Numerical models were utilized to predict peak groundwater activities resulting from SBW tank failure. Detailed explanations of models and parameters are provided in Shafer (1999) and OU3-13 RI/BRA (Rodriguez et al. 1997).

A screening analysis was performed to assess the impact of the modeled peak groundwater activities by comparing the modeled activities to MCLs as outlined in OU3-13 RI/BRA (Rodriguez et al. 1997). The predicted groundwater activity for I-129 is 0.9 pCi/L, which is below the 1.0 pCi/L MCL for I-129. The predicted groundwater activity for plutonium total (Pu-239, Pu-240, and Pu-242) is 0.9 pCi/L, which does not exceed the 15 pCi/L MCL for alpha-particle emitters such as plutonium. The predicted groundwater activities for other radionuclides (i.e., Am-241, Sr-90, Tc-99, U-234, U-238) present in the SBW tank are less than their respective MCLs (Table C.4-21).

For comparison purposes, the predicted effects of historical releases from INTEC operations were compared to predicted releases associated with DBE22. Predicted peak groundwater activities from historical releases for I-129 (9.0 pCi/L), Sr-90 (8.1 pCi/L) and plutonium-total (36 pCi/L) would exceed the MCLs in the year 2025, 2095, and 3585, respectively. The expected I-129 activities would increase 9 percent from 9.0 pCi/L to 9.9 pCi/L if the accident associated with DBE22 should occur. The expected Sr-90 activities would not increase if this major earthquake should occur and result in SBW release from the tank. Likewise, the expected plutonium radionuclide activities would not substantially increase (from 36 pCi/L) if this accident should occur.

Table C.4-21. Design basis events that produce groundwater impacts.

AA	Process title	Design basis events	Constituent	MCL (µg/L or pCi/L)	Peak groundwater concentration (µg/L or pCi/L)
22	Long-Term Onsite Storage of SBW	An earthquake causes the failure of a SBW tank vault with subsequent tank rupture and a release of SBW directly to groundwater.	Iodine-129 Plutonium-total Strontium-90	1 15 8	0.9 0.9 <8.0

MCL = Maximum Contaminant Level; µg/L = micrograms per liter; pCi/L = picocuries per liter.

The abnormal event for AA22 (Table C.4-22), intrusion into an SBW tank, would result in the migration of the radionuclides present in the SBW located in the Tank Farm tanks and was evaluated using a linear approximation, the impact of a 10 percent release would be about 10 percent of the results calculated for the seismic failure of a tank discussed above. Thus, the predicted groundwater activity for iodine-129 is 0.09 picocuries per liter, which is below the 1.0 picocuries per liter Maximum Contaminant Level for iodine-129. The predicted groundwater activity for plutonium total (plutonium-238, plutonium-239, plutonium-240, and plutonium-242) is 0.09 picocuries per liter, which is below the 15 picocuries per liter Maximum Contaminant Level for alpha-particle emitters such as plutonium. The predicted groundwater activities for other radionuclides present in the SBW tanks provide groundwater radionuclide concentrations that are small fractions of their respective Maximum Contaminant Levels.

Table C.4-22. Abnormal events that produce groundwater impacts.

AA	Process title	Abnormal events	Constituent	MCL (µg/L or pCi/L)	Peak groundwater concentration (µg/L or pCi/L)
02	New Waste Calcining Facility High Temperature & Maximum Achievable Control Technology Modification	A leak of kerosene through failed process connections. The entire contents of the tank could be released. Damage to the environment could be incurred if kerosene enters the groundwater.	Benzene in kerosene	5	120
22	Long-Term Onsite Storage of SBW	Accidental intrusion by unauthorized persons unprepared for contact with radioactive materials could result in a groundwater release of materials.	Iodine-129 Plutonium-total Strontium-90	1 15 8	0.9 0.9 <0.8

MCL = Maximum Contaminant Level; µg/L = micrograms per liter; pCi/L = picocuries per liter.

The predicted maximum contaminant levels from accident scenarios resulting in major groundwater releases are summarized in Table C.4-21 to C.4-23. In these summary tables, the organic and radioactive release contamination predictions are compared with EPA Maximum Contaminant Level values. From the summary, it can be concluded that groundwater releases involving organic constituents add substantially to the remediation requirements for INTEC while those involving radioactive constituents (ABN22 and DBE22) may not exceed the cost-effective limits of current remediation technology. Detailed explanation of modeling input parameters, source inventories, and results are contained in DOE (1998a) supporting this accident evaluation.

Table C.4-23. Beyond design basis events that produce groundwater impacts.

AA	Process title	Beyond design basis	Constituent	MCL (µg/L) or pCi/L)	Peak groundwater concentration (µg/L or pCi/L)
02	New Waste Calcining Facility High Temperature & Maximum Achievable Control Technology Modification	An aircraft impact results in the failure of both kerosene storage tanks and a subsequent fire. The primary hazard of this accident is not in the combustion products themselves but in the potential to result in an "external event fire" that impacts other processes.	Benzene	5	180

MCL = Maximum Contaminant Level; µg/L = micrograms per liter; pCi/L = picocuries per liter.

C.4.1.6 Integrated Risk to Involved Workers

Results of the point estimates of involved worker risk are given in Figure C.4-7, while mean values of the Monte Carlo simulations are summarized in Figure C.4-8. In Figures C.4-7 and C.4-8, the relative contributions from industrial accidents, occupational exposures, and facility accidents are delineated for each HLW processing alternative. A comparison of the simulated life cycle means versus point estimates is provided in Figure C.4-9.

From Figures C.4-7 through C.4-9 several conclusions can be drawn:

- Mean values of involved worker risk from the simulations are higher than those obtained from point estimates. Involved worker risk for all alternatives are sensitive to parameters such as the number of worker years of exposure, the rate of industrial accident fatalities, and the frequency of radiological

Figure C.4-7. Point estimates of integrated industrial worker risk for HLW processing alternatives

Figure C.4-8 Simulation of integrated industrial worker risk for HLW processing alternatives

Figure C.4-9 Comparison of integrated involved worker risk simulation means with point estimates for HLW processing alternatives release accidents. The simulated means tend to bound the potential for involved worker risks by encompassing in the distributions of these variables, particularly upper bounds that represent relatively unlikely but possible conditions. Consistent with the state of knowledge regarding projects and activities associated with implementation of alternatives, the simulations provide a more bounding and hence more reliable basis for comparing alternatives at this time.

- Estimates of involved worker risk due to industrial accidents do not favor alternatives that require the largest amount of manpower during implementation. Thus, alternatives such as Planning Basis that encompass the largest requirements for facility construction as well as the longest facility operation campaigns, could pose risk to involved workers from industrial accidents that is a full order of magnitude higher than that posed by less ambitious alternatives.

- Estimates of involved worker risk due to facility accidents do not favor alternatives that are vulnerable to bounding accident scenarios with high probabilities of occurrence or large radioactive or chemical releases. Alternatives such as No Action and Continued Current Operations that do not address the basic issue of reducing releasable material inventories have the highest predicted combinations of likelihood and consequences for bounding accidents. As such, the contribution of facility accidents to involved worker risk for these alternatives are as much as an order of magnitude higher than the contribution for the other alternatives that actively reduce health and safety risk over time.

- Industrial accidents are, for most of the alternatives, the largest contributors to involved worker risk. Therefore, estimates of integrated involved worker risk (including all sources) favor the alternatives such as No Action, Continued Current Operations, and Minimum INEEL Processing that involve less site activity over time. It should be remembered, however, that risks posed by transportation and activities at the Hanford site are not included in the estimates of involved worker risk for the Minimum INEEL alternative.

C.4.1.7 Conclusions and Comments

C.4.1.7.1 Integrated Accident Analysis Cross Section by Alternative

The accident evaluations presented in Sections C.4.1.3 and C.4.1.4 provide information on bounding scenarios for each HLW alternative that result from implementing each process element. This evaluation identifies those process elements that may pose higher accident risks than others. Integrating this information provides a clearer picture of the overall risk associated with each alternative. Thus, the decisionmaker can determine if a waste processing alternative has one dominant accident sequence or a series of accidents with similar consequences.

An additional benefit of alternative correlation is determining if there are common cause initiators for multiple accident scenarios for a given treatment alternative. For instance, a seismic event may result in structural damage and release of radiological or chemical inventories from several process elements. Individually, the accidents initiated by a seismic event may not have significant consequences. The seismic event may produce severe consequences when the effects from the individual scenarios are summed together for an alternative.

Table C.4-24 summarizes the crosscut evaluation of the applicable accidents for each alternative. As shown in the table, Process Element 3, "Calcine Retrieval and Transport," and Process Element 15, "Additional Off-Gas Treatment Processes" produced bounding radiological or chemical accidents for each alternative/option except the No Action and Continued Current Operations Alternatives. AA02 and AA22 produce bounding groundwater releases for the various alternatives.

C.4.1.7.2 Groundwater versus Airborne Releases

The focus of this evaluation was on airborne releases capable of producing health effects due to acute exposures. There were also several groundwater releases that were identified in the evaluation that could result in health effects due to prolonged exposures. Typically, in the National Environmental Policy Act accident analysis, it is assumed that chronic pathways to the environment can be remediated or at least can be prevented from severely impacting human receptors. If the evaluation were conducted without taking into consideration these types of mitigation measures, several groundwater releases could produce bounding accidents.

Nevertheless, since historic experience with nuclear weapons, weapons testing, and nuclear accidents tends to validate concerns over the public health impacts of accidental air releases while groundwater releases can only be theorized as impacting a member of the public in the far future, preferences for waste processing alternatives based on accident analysis should be based mainly on the results of projected air release accidents.

C.4.1.7.3 Localized Hazards

The evaluation of several process elements identified accident scenarios resulting from operational errors (e.g., contact of incompatible materials during maintenance) that could result in localized hazards to personnel. The consequences associated with these accidents can be mitigated by protective gear that is donned during operations in hazardous environments. It was not anticipated that toxic and/or radiological hazards would be posed to co-located personnel or the public from these operational accidents since the release-producing mechanisms were not found to present an immediate threat to the integrity of buildings and containments used to control accidents at DOE nuclear facilities.

C.4.1.7.4 Common Cause Initiators

Common cause initiators were evaluated only in a limited sense. Toxic gas releases associated with Process Element 15, "Additional Off-Gas Treatment Processes" were identified as possible initiators in accident sequences involving operator incapacitation. Additionally, other initiators could also produce accidents in multiple process elements associated with an alternative/option. The primary concern in this area is in seismic events that could impact multiple facilities.

C.4.1.7.5 Sensitivity Discussion

The Idaho HLW & FD EIS accident analysis consequence modeling was performed for three receptors.

For each of these analyses, conservative assumptions were applied to obtain bounding results. For the most part, the assumptions in the HLW & FD EIS were consistent with those applied in other EIS documents prepared at the INEEL, such as the SNF & INEL EIS (DOE/EIS-0203-F) (DOE 1995). However, there were some assumptions that differed. Of the assumptions incorporated in the HLW & FD EIS consequence modeling, exposure pathways, exposure time, breathing rate, meteorology, and location (for the population dose) were some that had significant impact on the results. Appendix H (Table H-1) in the TRD summarizes the potential effects that may be observed if these assumptions are changed.

The approach that was taken in the Idaho HLW & FD EIS consequence modeling was done to ensure that a "safety envelope" was provided. As discussed above, this approach differs from the approach taken in other EIS's, such as the SNF & INEL EIS. Due to this, the results presented in the HLW & FD EIS are larger than the results that would have been obtained by applying the SNF & INEL EIS assumptions. However, the key issue at hand is that the Idaho HLW & FD EIS is providing a likely upper bound to the potential consequences for the accidents associated with the candidate alternatives. In addition, these conservative assumptions were incorporated in a consistent manner. Although adjustments to these assumptions will modify the absolute magnitudes of the predicted consequences, they will not modify the relative ranking of the modeled scenarios. So the set of bounding scenarios are anticipated to remain the same. More detail can be found in King (1999a).

C.4.1.7.6 Comparison of HLW Processing Alternatives Based on Facility Accidents

Bounding accident scenarios in the HLW EIS bound the consequences of accidents that could occur as a result of implementing a waste processing alternative. Bounding accident scenarios contribute much but not all of the risk associated with implementation of an alternative. In order to compare the risk of implementing an HLW processing alternative based on facility accidents, it is appropriate to construct a basis for estimating the total risk of implementation rather than simply comparing the largest accidents posed by an alternative. As a prelude to this comparison, an understanding of the relationship between risk due to bounding accident scenarios and the total risk of implementation must be developed.

The process used to compare health and safety risk to the public as a result of implementing each of the HLW processing alternatives is described in Table C.4-25 and its accompanying description information.

Table C.4-25 provides an integrated perspective on risk to collocated workers and the public as a result of bounding facility accidents for all the waste processing alternatives. In Table C.4-25, the contribution to public risk (in LCF) from identified bounding accident scenarios is presented as a fractional increase over the background cancer rates for the total affected population in the EIS.

The information in Table C.4-25 supports comparison of treatment alternatives based on the risk of facility accidents.

- Alternatives that are vulnerable to bounding accident scenarios with the highest probabilities of occurrence and estimated consequences exhibit the highest potential for risk due to facility accidents. Alternatives such as No Action and Continued Current Operations, that do not address the basic issue of reducing releasable material inventories have the highest predicted combinations of likelihood and consequences for bounding accidents, thus posing risk to the public several orders of magnitude greater than alternatives that actively reduce risk over time.

- Alternatives requiring the use of separation technology could pose relatively high risk from facility accidents. Historical experience indicates that such processes could have a relatively high likelihood of accidents that result in significant and energetic release of materials. The Transuranic Separations Option, in particular, illustrates this vulnerability for the design basis event.

- Some alternatives could be vulnerable to release producing events that would make DOE safety criteria and guidelines difficult to adhere to. This conclusion is based on very preliminary information however, and it indicates only a need for careful consideration of facility safety as part of alternative implementation.

C.4.2 FACILITY DISPOSITION ACCIDENTS

C.4.2.1 Introduction

C.4.2.1.1 Purpose

The purpose of Section C.4.2 is to analyze alternatives for the disposition of INTEC facilities. Each waste processing alternative and facility disposition option requires an analysis of potential facility accidents as one of the environmental impacts, particularly to human health and safety, associated with its implementation. DOE has performed an accident analysis to identify environmental impacts associated with accidents that would not necessarily occur, but which are reasonably foreseeable and could result in significant impacts. Since the potential for accident and their consequences varies among different facility disposition options, facility disposition accidents may provide a key discriminator among the HLW & FD EIS alternatives. Accidents are defined according to the National Environmental Policy Act as undesired events that can occur during or as a result of implementing an alternative and that have the potential to result in human health impacts or indirect environmental impacts.

Potential facility disposition accidents pose health impacts to several groups of candidate recipients. Along with workers performing disposition activities at each facility (involved workers), workers at nearby INEEL facilities (noninvolved workers) and the offsite population could be exposed to hazardous materials released during some accident scenarios. Potential facility disposition impacts to human health arise from the presence of radiological, chemical, and industrial (physical) hazards.

Each EIS alternative for the treatment, storage, and disposal of HLW at INTEC affects or includes several major INTEC facilities, such as the New Waste Calcining Facility, Tank Farm, and bin sets. Clean closure, performance-based closure, and closure to landfill standards are the three major alternatives that are being considered by DOE for each HLW facility disposition.

Approach

The approach adopted by DOE is illustrated in Figure C.4-10. As shown, potential facility disposition impacts for noninvolved workers and members of the offsite population are analyzed differently than for involved workers. Only involved workers are subject to industrial accident hazards, such as falls or electrical shocks; however, all three groups could be exposed to radioactivity and/or hazardous chemicals released by a severe accident.

For noninvolved workers and the offsite population, the maximum plausible accident identified for disposition of each facility is compared to the maximum credible accident postulated for normal operation of that facility. (In this appendix, the term "maximum plausible accident" is used to indicate the bounding accident during facility disposition, while the term "maximum credible accident" is used to indicate the bounding accident during facility operation.) If the maximum credible accident during facility operation bounds the maximum plausible accident during facility disposition, then facility disposition accidents are presumed to be bounded by those events already considered in facility operation. As such, facility disposition activities would not be expected to introduce new or previously undisclosed sources of risk to noninvolved workers and the offsite population.

Data sources used to establish maximum credible accidents during facility operation include safety assurance documentation such as safety analyses for HLW processes at INTEC, and EIS estimates for bounding facility events that are included in waste processing alternatives. Comparisons between disposition events and corresponding operations accidents are based on relative differences in inventories of radioactive materials and hazardous chemicals, changes in mobility of these substances, and changes in the energy available for accident initiation and propagation. These changes occur to some extent while a facility undergoes deactivation. For individual facilities, the combination of inventory reductions, immobilization of residuals, and removal of energy sources produce potential disposition impacts that are less severe than those posed by acceptable hazards from current operations. This analysis indicates that a maximum plausible disposition event for a given facility has significantly less potential impact than a corresponding operations accident infers and that risks at that facility would not be increased by prospective actions taken to implement an EIS alternative.

Involved workers would be exposed to numerous industrial physical hazards during facility disposition activities, in addition to hazards from residual chemicals and radioactive materials following facility deactivation. The industrial hazards to involved workers likely would not diminish when inventories of

Figure C.4-10. Impact assessment methodology for hypothetical disposition accidents in INTEC facilities chemicals and radioactive substances are removed or immobilized. These accidents such as falls from scaffolding are essentially independent of the radioactive and chemical inventories, the mobility of these materials, and the energy available to release these inventories. Furthermore, the likelihood of industrial accidents may increase during facility disposition, relative to facility operations, because more industrial labor is required during active phases of disposition.

There is another reason why occupational impacts to involved facility workers cannot simply be bounded by the maximum postulated accident for operations in the same manner as for potential impacts to noninvolved workers and members of the offsite population. Many facility systems that mitigate consequences of operations accidents to involved workers, such as fire protection systems, may no longer be available during disposition, especially during the latter phases such as demolition. It is also possible that involved workers may encounter unforeseen radiological or chemical hazards during disposition without the benefit of adequate protective equipment. For example, process tanks or lines that are declared empty in facility documentation may still contain enough radioactivity to require shielding or remote handling for disassembly.

For these reasons the strategy for involved workers reflected in Figure C.4-10 is to compare the potential impacts from disposition accidents with respect to the closure options under consideration. For industrial hazards, potential impacts (injuries/illnesses and fatalities) are assumed proportional to disposition labor hours. As discussed below, a clean closure option requires more disposition labor than a performance-based closure, which requires more labor than closure to landfill standards. Consequently, clean closure poses the largest total risk of industrial accidents to involved workers, while closure to landfill standards poses the least total risk. Similarly, impacts from radiological hazards in terms of total rem exposure are bounded from below by allowable cumulative doses to workers and are calculated from the estimated duration (hours) of radiation worker labor. Facility-specific hazards from hazardous chemical residues are more difficult to quantify with available information. However, inferences can be drawn by assuming that impacts are related to amounts of disposition labor under hazardous conditions, because clean closure requires more disposition activity in close proximity to chemical hazards, followed by performance-based closure and then closure to landfill standards. Thus, potential impacts to involved workers from chemical residues should demonstrate the same trend among closure options as industrial and radiological accidents.

Scope

This analysis postulates facility disposition accidents that could occur during facility closure and have the potential to harm workers, the offsite population, and the environment. This analysis of facility disposition accidents was applied only to those existing INTEC facilities that are significant to the treatment, storage, or generation of HLW. New facilities required for the waste processing alternatives are not considered in the analysis because the design of these facilities has not been finalized, and the designs would include features to facilitate dispositioning (DOE 1989). Thus, new HLW facilities are assumed to have minimal radioactive and hazardous material inventories remaining at the time of disposition and a low potential for significant accidents.

As described in Section 3.2.2 of this EIS, DOE used a systematic process to identify which existing INTEC facilities would be analyzed in detail for this EIS. These facilities selected for detailed analysis are assumed to have material inventories that require careful consideration of the potential for accidental release into the environment at closure. The results of the DOE facility selection process are documented in Section 3 of this EIS in Table 3-4. Table 3-4 has been validated as an appropriate basis for the analysis of potential disposition impacts to involved workers in Section C.4.2.4. This section also is applicable to inter-facility transport lines that are not directly associated with individual INTEC facilities.

Facilities that pose short-term radiological and chemical hazards to noninvolved workers and the offsite population are presented in Table C.4-26; the emphasis was on those facilities where potential accidents could rapidly disperse radionuclides and/or hazardous chemicals beyond the immediate working area. Selection guidance was obtained from a prior study, the *Comprehensive RI/FS for the Idaho Chemical Processing Plant OU 3-13 at the INEEL Part A, RI/BRA Report (Rodriguez et al. 1997)*, which identified those facilities with airborne release and direct exposure pathways.

For purposes of the facility disposition accident analysis, HLW facilities that have only "groundwater pathways" for hazardous material releases were not assessed for potential impacts to noninvolved workers and the offsite population. Facility disposition accident releases to the groundwater pathway would not be expected to produce a short-term health impact to the public because DOE could remediate the affected media or restrict public access to it. Groundwater impacts are presented in the TRD only when the potential for the consequence of an accident is so great that the cost of remediation was intractable and had to be assessed. Also, due to limitations on material, accessibility, and available energy for release, the possibility of such large events can be categorically eliminated or least assumed to be bounded by the

Table C.4-26. Existing INTEC facilities with significant risk of accidental impacts to noninvolved workers and to the offsite population.

Tank Farm	
CPP-713	Vault containing Tanks VES-WM-187, 188, 189, and 190 with supporting equipment and facilities
CPP-780	Vault containing Tank VES-WM-180 with supporting equipment and facilities
CPP-781	Vault containing Tank VES-WM-181 with supporting equipment and facilities
CPP-782	Vault containing Tank VES-WM-182 with supporting equipment and facilities
CPP-783	Vault containing Tank VES-WM-183 with supporting equipment and facilities
CPP-784	Vault containing Tank VES-WM-184 with supporting equipment and facilities
CPP-785	Vault containing Tank VES-WM-185 with supporting equipment and facilities
CPP-786	Vault containing Tank VES-WM-186 with supporting equipment and facilities
Bin Sets	
CPP-729	Bin set #1 with supporting equipment and facilities
CPP-742	Bin set #2 with supporting equipment and facilities
CPP-746	Bin set #3 with supporting equipment and facilities
CPP-760	Bin set #4 with supporting equipment and facilities
CPP-765	Bin set #5 with supporting equipment and facilities
CPP-791	Bin set #6 with supporting equipment and facilities
CPP-795	Bin set #7 with supporting equipment and facilities
Process Equipment Waste Evaporator and Related Facilities	
CPP-604	Process Equipment Waste Evaporator
CPP-605	Blower Building
CPP-649	Atmospheric Protection Building
CPP-708	Main Exhaust Stack
CPP-756	Prefilter Vault
CPP-1618	Liquid Effluent Treatment and Disposal Facility
Fuel Processing Building and Related Facilities	
CPP-601	Fuel Processing Building
CPP-627	Remote Analytical Facility
CPP-640	Head End Process Plant
Other Facilities	
CPP-659	New Waste Calcining Facility
CPP-666/767	Fluorinel Storage Facility and Stack
CPP-684	Remote Analytical Laboratory

a. Derived from Table 3-4 and Rodriguez et al. (1997).

facility accidents already considered. Because current facility data on the type and quantities of miscellaneous hazardous materials were not available, no definitive analysis was done with respect to the chemical content and potential impact of incidental, hazardous materials at the facilities. Hazardous materials expected to be present during facility disposition activities include kerosene, gasoline, nitric acid, decontamination fluids, and paints. The assumption was made that closure activities would include the disposal and cleanup of hazardous materials to the maximum extent practicable in accordance with the current decommissioning manuals and regulations. Moreover, during INTEC-wide operations, the bounding release scenario for hazardous chemicals with the greatest potential consequences to noninvolved workers and the offsite population is a catastrophic failure of a 3,000-gallon ammonia tank. This scenario results in ammonia releases greater than ERPG-2 concentrations at 3,600 meters. Here "exposures to airborne concentrations greater than ERPG-2 values for a period greater than 1 hour results in an unacceptable likelihood that a person would experience or develop irreversible or other serious health effects or symptoms that could impact a person's ability to take protective action." This accident scenario also bounds potential chemical releases for the facility disposition analysis cases.

End Products

There are two end products of this HLW facility disposition analysis: (1) for potential impacts to noninvolved workers and to members of the offsite population, a comparison of "Maximum Plausible Accident Scenarios" for each applicable facility disposition activity and closure option with impacts anticipated during facility operation and (2) for involved workers, estimates of relative health and safety risk among the facility closure options. In both cases risks will not be estimated in terms of absolute impact on the health and the environment.

C.4.2.2 Facility Closure

The three facility disposition alternatives considered by DOE and included in this analysis are defined below. (Subsequent use of the Tank Farm and bin sets as a Low-Activity Waste Disposal Facility is not included here because accidents associated with this activity were addressed in the TRD.

Clean Closure

Hazardous wastes and radiological and chemical contaminants, including contaminated equipment, would be removed from the facility or treated so that residual radiological and chemical contamination is indistinguishable from background concentrations. Use of facilities (or the facility sites) after clean closure would present no risk to workers or the public from radiological or chemical hazards. Clean closure may require total dismantlement and removal of facilities.

Performance-Based Closure

For radiological and chemical hazards, performance-based closure would be in accordance with risk-based criteria. The facilities would be decontaminated so that residual waste and contaminants no longer pose any unacceptable exposure (or risk) to workers or to the public. Post-closure monitoring may be required on a case-by-case basis. Closure methods would be dictated on a case-to-case basis depending on risk.

Closure to Landfill Standards

The facility would be closed in accordance with Federal and state requirements for closure of landfills. Closure to landfill standards is intended to protect the health and safety of the workers and the public from releases of contaminants from the facility. This could be accomplished by installing an engineered cap; establishing a groundwater monitoring system; and providing post-closure monitoring and care of the waste containment system, depending on the type of contaminants.

C.4.2.3 Analysis Methodology for Noninvolved Workers and the Offsite Population

The accident analysis team for the facility disposition options performed a systematic review of available data from applicable INTEC safety analysis reports, safety reviews, HLW facility closure studies, and EIS technical requirements data that were generated in the TRD. The maximum plausible accident scenario, selected for the HLW facilities with airborne release and direct exposure pathways, is compared to a bounding accident scenario that was postulated during normal facility operations in safety analysis reports or in the TRD. In some cases, the best available references have not been updated to reflect cessation of fuel processing operations at INTEC. Criticality may still be cited as the maximum postulated operations accident as a result of previous processing or storage operations at the facility. Although such an event would no longer be possible, its potential for occurrence has been evaluated and “accepted” as part of the facility safety management requirements by DOE.

A seven-step process is used to select and compare the bounding accident scenarios for facility disposition activities.

Facility Description

DOE collected and reviewed facility descriptions that were obtained from current EIS alternative treatment studies, EIS facility closure studies, INTEC reports and studies, Lockheed Martin Idaho Technologies Company feasibility studies, and previous DOE HLW studies. The facility description reviews focused on the facility's operational function; primary activities; location at INTEC; structural materials; type of equipment and process lines; shielding provisions; heating, ventilation, and air conditioning systems; material inventories; and other factors pertinent to potential facility disposition accidents. Particular attention was placed on structure design and materials that could impact the safe, efficient, and complete removal of radioactive and hazardous materials.

Facility Closure Condition

DOE identified three types of facility closures appropriate for HLW facility disposition: clean closure, performance-based closure, and closure to landfill standards. For the INTEC Tank Farm and bin sets, which would contain most of the residual radioactivity, all three facility disposition alternatives were evaluated and are active considerations. For the remaining INTEC facilities, a single facility disposition alternative was selected, except for the FAST Facility and Stack (CPP-666 and -767) where two facility disposition alternatives were evaluated. The material inventories associated with these facilities would be much less than that of the Tank Farm and bin sets. Therefore, the overall residual risk to noninvolved workers and the offsite population from closure of INTEC HLW facilities would not change significantly due to the contribution of a potential accident for these facilities. Also, the type of closure is considered in estimation of critical factors that could impact the maximum plausible accident: material at risk, energy, and mobility.

Material at Risk at Closure

The severity or eventual consequences of any potential facility disposition accident is directly proportional to the type, quantity, and potential energy of material at risk and the resultant source term. For this analysis, it is assumed that the most of the materials at risk would be removed during the facility cease-use period prior to closure activities. However, the estimated material at risk could be much greater if significant quantities of radioactive and hazardous materials were inadvertently "left behind" in areas that are assumed to be clean.

In the case of the bin sets, the Calcine Retrieval and Transport Project along with subsequent closure activities would reduce the quantities of material at risk by nearly two orders of magnitude below normal operation levels. This significant reduction in material inventory during facility closure activities is one of the primary assumptions that supports the selection of bounding accidents from facility operations accidents to bound potential closure accidents.

Contaminant Mobility at Closure

Contaminant mobility in the facility environment is a function of the type and construction of the facility, the location of the facility with respect to exposure pathways, the characterization and location of the contaminants, and the type of closure operations. These mobility factors and others were considered by DOE in estimating the potential contaminant mobility for each type of HLW facility. In facilities where most of the residual contamination was left in tanks or internal bins or otherwise inaccessible places, the contaminant materials were deemed relatively unavailable for release and not susceptible to natural or external phenomena accident initiators.

Available Energy for Accident at Closure

As was the case for determining bounding accident scenarios during the treatment alternative operations, the accident "initiating events" considered for the facility closure options include fires, explosions, spills, nuclear criticality, natural phenomena, and external events. Internal initiators such as human error and equipment failures occur during operations that trigger the fires, explosions, and spills. Natural phenomena initiators include floods, tornadoes, and seismic events. External initiators include human-caused events during decommissioning, decontamination, closure, or a non-related aircraft crash. Generally, the external initiators are the most probable initiators for bounding facility accidents that cause major structure damages and materials releases to the environment.

Maximum Plausible Accident at Closure

The maximum plausible accident is the largest credible accident during facility closure that could be hypothesized using available information. Determination of the maximum plausible accident provides an "accident benchmark" compared with the maximum credible accident for facility operations. Also, the maximum plausible accident during closure may highlight the need for additional safety procedures or equipment to be considered in future safety analysis reports.

Table C.4-27 summarizes the results of the analyses of facility closure accidents. For additional information on the contents of Table C.4-27, the reader may refer to the appropriate facility discussion in the TRD for relevant details.

C.4.2.4 Industrial Hazards to Involved Workers During Facility Disposition

Since the risk of additional impacts on non-involved workers and the public as a result of radiological and chemical release accidents is small, additional risk to involved workers may supply a key discriminant among facility disposition alternatives. Involved workers may incur health effects from three sources during the implementation of facility disposition alternatives.

1. Industrial accidents, particularly those occurring in the course of decontamination, construction, and demolition activities. An example would be the use of heavy equipment in unstable surroundings during removal of equipment or materials.

2. Increased occupational doses as a result of exposure to contaminated ground and facilities, under conditions where exposures are unplanned for or the level of shielding and protection is reduced. An example would be exposure of workers to unmarked or highly contaminated transport lines between facilities.

3. Chemical release accidents that impact involved workers but not uninvolved workers or the public.

Specific hazards and their relative contributions to involved worker risk will vary among facilities and the closure options selected for them. In general, clean closure requires more interaction between workers and hazards than a performance-based closure, while a closure to landfill standards requires the least interaction.

Industrial Hazards. The purpose of this analysis to estimate the potential impacts to involved workers from these hazards during disposition of the HLW facilities pertinent to this EIS. Industrial impacts are estimated in terms of injuries, illnesses, and fatalities that are sustained on the job and reported according to Occupational Safety and Health Administration regulations. The total number of injuries/illness and fatalities that could occur at each of the existing HLW facilities during the facility disposition period are estimated according to total labor hours. Thus, the EIS alternative evaluators are provided with an additional discriminator, a relative assessment of the total number of reportable injuries/illness and fatalities for disposition of the existing HLW facilities. The absolute numbers of calculated industrial incidents are dependent on preliminary estimates of disposition labor for each facility, which are highly uncertain given the preliminary nature of facility disposition plans. For example, the estimates also do not include disposition of transport lines between individual facilities, for which projection of labor are not yet available. Nevertheless, the relative numbers of injuries/illnesses and fatalities among facility disposition options offers a valuable perspective on the potential impacts to involved workers.

Methodology. The basic assumption of this analysis is that industrial incidents are directly proportional to the total number of worker hours for the disposition of each facility. Thus, the total number of injury/illnesses and fatality cases for each existing facility is determined by multiplying the estimated total worker hours during facility disposition times an assumed incident rate for injuries/illnesses and fatalities. It should be noted that exact frequency of injuries/illnesses and fatalities is less critical than the consistency with which these rates are applied to different facility disposition alternatives, so that the impact of facility disposition to involved workers can be put in perspective as a potential discriminating factor for evaluating EIS alternatives.

The estimated total worker hours for each facility disposition were obtained from several Lockheed Martin Idaho Technologies Company Engineering Design Files and Project Data Sheets performed for the existing facility closures associated with this HLW & FD EIS. Specific Engineering Design Files and Project Data Sheets are listed in the TRD.

The average hazard incident rates were obtained by reviewing several historical DOE and U.S. Government records for actual injury/illness and fatality rates during construction work in the recent past. The average INEEL and private industry injury/illnesses and fatality incident rates in the *SNF & INEL EIS* (DOE 1995), from the Computerized Accident Incident Reporting System industrial accident database through 1997, and from a Bayesian update to include 1998 data (Fong 1999). The exact estimators used in this industrial accident risk comparison are discussed in the TRD. The incident rates are per 100 man-years or 200,000 construction hours, which is a common benchmark used by DOE, Occupational Safety and Health Administration, and the Bureau of Labor Statistics. These selected rates are 6.2 and 13.0 injuries/illnesses per 200,000 worker hours, and 0.011 and 0.034 fatalities per 200,000 worker hours for INEEL and private industry, respectively. Corresponding ranges of estimated impacts are provided in the TRD. Actual rates for INTEC HLW disposition activities likely would be equal to or greater than the DOE construction rates but less than the private industry construction rates. Thus, the lower and upper estimates of expected incidents were averaged for calculating the results in the summary table (Table C.4-28).

Table C.4-28 presents the analysis results for industrial impacts to involved workers. The available DOE data do not consistently disclose the type of facility closure type assumed for the “Other Facilities.” Therefore, for purposes of this table, the estimated total labor hours and resultant incidents for the “Other Facilities” are assumed to be equal for all three types of closure.

Table C.4-28. Industrial hazard impacts during disposition of existing HLW facility groups using "average DOE-private industry incident rates" (per 200,000 hours).

Facility groups	Total removal clean closure		Performance-based closure/clean fill		Closure to landfill standards/clean fill	
	Injuries/illnesses	Fatalities	Injuries/illnesses	Fatalities	Injuries/illnesses	Fatalities
Tank Farm	750	1.79	30	0.07	16	0.04
Bin sets	134	0.32	103	0.24	48	0.11
Other facilities	149	0.33	149	0.33	149	0.33
Total incidents	1,033	2.44	282	0.64	213	0.48

Table C.4-28 shows the estimated number of injuries/illnesses and fatalities for the three major closure options, based on the average DOE-Private Industry rate. This incident rate used in Table C.4-28 is the average of the "lower bound DOE rate" and the "upper bound Private Industry rate" for construction work. This table shows that the estimated number of incidents varies considerably with the type of closure option. Note that the Clean Closure Alternative has by far the greatest number of injuries/illnesses and fatalities; the Performance-Based Closure Alternative has fewer incidents and the Closure to Landfill Standards Alternative has the least number of estimated incidents. This result can be attributed to the large number of disposition man-hours and project years required by the Clean Closure Alternative. This option also involves more demolition and heavy equipment operation than the other two closure alternatives. The total number of incidents for the Performance-Based and Landfill Closure Alternatives are nearly equal, within the limitations on the data currently available for the "Other Facilities."

Accident/Injury rate for INEEL from CAIRS are slightly lower than those in the SNF & INEL EIS that are derived from complex-wide experience while the fatality rate for INEEL from the same information base is an order or magnitude higher. There are two possible explanations. It could be argued that fatalities are stochastic events and the small size of the fatality data base for INEEL does not provide an acceptable statistical basis for projecting a radically different fatality rate from the underlying complex-wide rate that is consistent with accident/injury experience at the site. Alternatively, it could be argued that the currently high fatality rate does represent a systemic safety issue at the site, one that is currently being addressed through aggressive Integrated Safety Management and related safety improvement efforts.

Radiological Hazards. In addition to estimating the nonradiological impacts of occupational hazards to the INTEC involved worker, it is important to estimate the radiological impacts that could be sustained during facility disposition. For this purpose, estimates for the total radiation dosage sustained by the involved workers during the facility disposition period were used for this analysis. Data for this radiological parameter were obtained from Engineering Design Files and Project Data Sheets listed in the TRD and provide the EIS analyst additional inputs for relative comparisons among the EIS alternatives. As for industrial hazards, specific information is not currently available for transport lines that are not associated with any individual facility. This omission could be significant if any contamination has leaked from transport lines to the surrounding soil, which could pose a distinct risk of accidental radiation exposure to unsuspecting involved workers.

Facility totals for worker radiation dosage are assumed to be directly proportional to the total number of radiation worker-years needed for each facility disposition alternative. Radiation worker-years are defined as the product of the number of workers working in radiation areas times the number of closure years for each facility. Thus, to determine the total radiation dosage per facility, the number of radiation man-years was multiplied by the dosage rate, i.e. total rem per worker per year.

Table C.3-8 presents the total radiation dosage to the exposed radiation workers for each facility group by closure type. An average dosage rate for each facility closure was obtained from the Engineering Design Files and Project Data Sheets mentioned previously. The available DOE data do not disclose the type of facility closure assumed for the “Other Facilities.” Therefore, for purposes of this table, the estimated total labor hours and resultant incidents for the “Other Facilities” are assumed to be equal for all three types of closure. The latent cancer fatalities that result from this population exposure can be estimated by multiplying the total dosage (person-rem) by 4×10^{-4} latent cancer fatalities per person-rem. This dose-to-risk factor is based on the *1990 Recommendations of the International Commission on Radiation Protection* (ICRP 1991).

As was the case for the industrial incidents shown in Table C.4-28, the greatest negative impacts to the involved worker are predicted for clean closure, followed by performance-based clean closure, and then by closure to landfill standards.

As discussed further below for chemical hazards, the above analysis does not fully cover unforeseen, stochastic events with local consequences that may be difficult to predict in statistical fashion. One hypothetical example is a work team being exposed to strong radioactivity at an unexpected location, such as by excavating a buried source of powerful gamma radiation without warning and without adequate shielding. Even if the work team promptly evacuates, the amount of worker exposure during such an incident would be of major occupational significance. Events of this nature may be more likely during facility activities than during standard operational conditions. Therefore, impacts of major unforeseen events are not necessarily reflected in these exposure predicitions, because the dosage rate used was primarily derived from facility operations data.

Chemical Hazards. Available data related to chemical hazards were evaluated in the facility disposition Engineering Design Files. The objective was to find a relative indicator of worker exposure to chemical hazards by which Occupational Safety and Health Administration-reportable events could be predicted. Unlike radiation worker labor hours, however, no prediction of labor hours under chemically hazardous conditions is reported in the Engineering Design Files. Efforts also were made to utilize an indirect indicator, such as generation of hazardous waste, but sufficient information is not available for a valid estimator of relative impacts to involved workers. Because Engineering Design File data are preliminary, varying assumptions and estimating techniques have been employed among Engineering Design File authors. In addition, Engineering Design Files are updated frequently and new formats are introduced in the process, which prevents the compilation and interpretation of consistently comparable data for chemical hazards.

Even with more consistent, comprehensive Engineering Design File data, the purpose of this particular analysis would have been difficult to accomplish for the same reason as mentioned for radiological hazards. That is, databases drawn from DOE operations or the commercial chemical industry would not fully encompass the unique challenges facing involved workers during disposition of INTEC HLW facilities. By the time demolition occurs, some of these facilities will have been inactive for decades. Some facilities already have been in a shutdown condition for extensive periods. Under these circumstances, unanticipated exposures can be expected during active phases of disposition. For example, lines and tanks indicated as “drained and flushed” on facility documents are occasionally found with significant chemical and radiological inventories. However, whereas radioactivity often provides an easily detected warning, this is less true for chemical hazards. Characteristics of chemical residues also may change or deteriorate with time, posing hazards never encountered during normal handling and processing steps. Thus, consequences of an accidental chemical exposure to a work team can be worse than a comparable radiological event.

It is very likely that incidents of worker exposure to hazards chemical residues during disposition will follow the same pattern as found for industrial and radiological hazards. Clean closure would generally be labor-intensive and require the greatest worker effort during disposition. Performance-based disposition would need less overall labor than clean closure, but a performance-based option still would require extensive worker interaction in close proximity to potential hazards. Meanwhile, closure to landfill standards would be both relatively rapid and more amenable to remote, mechanized equipment such as cranes and bulldozers. This line of reasoning on relative impacts among the closure options is likely to be especially true for unforeseen interactions with particularly dangerous chemical hazards. Thus, preliminary indications for chemical hazards are in harmony with the analyses of industrial and radiological impacts to involved workers.

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